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LAHORE, 1927.

(SECOND CIRCUIT)

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Proceedings of the Fourteenth Indian Science Congress.

CONTENTS.

*(Papers marked with an * are given by title only, without any abstract.)*

Plenary Meeting.

PAGE

Presidential Address: The unity of life. By Sir J. C. Bose, M.A., D.Sc., LL.D., F.R.S., C.S.I., C.I.E., KT. Founder and Director, Bose Research Institute, Calcutta 5

Section of Agriculture.

Presidential Address: The capacities of Indian cattle for food consumption and digestion. By F. J. Warth. M.Sc. .. 27

Papers.

*1. Influence of nutrition on human and animal welfare. By P. Lander 31

*2. Some dairy problems. By W. Smith 31

3. The effect of manuring a crop on the vegetative and reproductive capacity of the seed. By B. Viswa Nath and M. Suryanarayana 31

4. Breeding improved sugarcanes for the Punjab. By T. S. Venkatraman 32

5. Correlation between yield and some prominent characters in *Andropogon Sorghum.* By Messrs. Kottur and Chavan 32

6. The yielding power of a strain of Mysore-American cotton compared with that of Cambodia and Dhawar-American. By V. N. Ranganatha Rao. 32

7. An attempt to introduce and acclimatise *Andropogon Sorghum*, Var. *technicus* (broom-cord or broom-corn in United Province) with seed introduced from N.-W. Italy (Ligurian Province) and the agricultural and industrial possibilities of broom-corn cultivation. By S. S. Nehru 32

8. The seasonal composition of well waters as a means of study of soil nitrification changes. By Harold F. Annett 33

9. Seasonal variations of the nitrate content of soils. By H N. Batham and S. Nigam 33

10. The effect of varying concentrations of ammonia on the nitrifying power of the soil. By D. V. Bal. .. 33

11. An economical method of manuring with sunn hemp. By N. V. Joshi. 33

PAGE

12. Home made super and its effect on potatoes. By N. D. Vyas 34
13. The effect of sulphur oxidation on the microflora of activated sludge By C. V. Ramaswami Ayyar and Roland V. Norris 34
14. Sulphur oxidising organisms from activated sludge Part I. By C. V. Ramaswami Ayyar 34
15. The production of ammonia by soil fungi. By A. K. Thakore and Roland V. Norris 34
16. Aphids and lady-bird beetles. By G. R. Dutt. .. 35
17. Experimental control of sex-ratio and its bearing on lac cultivation. By S. Mahdihassan 35
18. The use of gypsum in the reclamation of bara. By Mukand Lal 35
19. The fate of irrigation water and rainfall in the soil. By B. H. Wilsdon 35
20. Mole drainage. By B. H. Wilsdon 35
21. Some studies on the growth of wheat plants and correlations between certain wheat characters, i.e., height of plant and length of head, etc., etc. By Jai Chand Luthra and Ranbir Singh 36
22. Some observations on the extent of fertilization of ovules in various cottons. By Jai Chand Luthra and Sardar Khan 36
23. Experiments on Egyptian cotton in Sind. By K. I. Thadani 36
24. Note on the mechanical analysis of soil. By A. N. Puri and B. M. Amin 37
25. Note on the hypothesis of "unfree water" in soils. By A. N. Puri 37
*26. Base exchange capacity of soils and a new method for finding it. By A. N. Puri 37
27. The value of seed testing. By R. D. Bose 37
28. The eradication of kans (*Saccharum spontaneum* L.). By Albert Howard 38
29. The mixing of cotton varieties. By A. Howard and S. C. Talesara 38
30. A method of improving the feeding value of straw-chaff. By A. Howard 38
31. Root development of paddy under different conditions of growth. By R. L. Sethi 38

Section of Mathematics and Physics.

Presidential Address: Some recent theories on magnetism. By Prof. D. M. Bose. M.A., Ph.D. 39

Papers

1. On a method of determining the ionisation potential of elements showing flame lines. By S. Datta and S. Ch. Sen 74
2. On the reversal of bands. By S. Datta 74

		Page
3.	Ionisation potentials and atomic sizes. By S. Ch. Biswas	75
4.	Contributions to atomic physics. Part II. Ionisation potential and periodic classification. By S. Ch. Biswas	75
5.	Thermal ionisation of elements. By N. K. Sur and K. Majumdar	76
6.	On hot wire anemometry. By B. L. Gupta	77
7.	Some observations on electricity produced by dust storms. By B. L. Gupta	77
8.	On the spectrum of argon. By D. K. Bhattacharyya ..	78
9.	Note on the spectrum of nickel. By P. K. Kichlu ..	78
10.	Series relation in the spectrum of copper. By P. K. Kichlu	79
11.	On an interpretation of the spectrum of cobalt. By N. K. Sur	80
12.	On the arc spectrum of bismuth. By G. R. Toshniwal..	81
13.	On the complete explanation of the spectra of the metals of the second group. By Meghnad Saha	81
14.	A note on the spectrum of neon. By Meghnad Saha ..	82
15.	Relative intensity of x-ray lines. By Y. Nishina and B. Ray	83
16.	On the irregularity of the *K*a doublet in the elements of lower atomic numbers. By D. M. Bose	83
17.	On Fresnel's convection coefficient in general relativity. By N. R. Sen	84
18.	On the dualistic nature of the radiation field. By S. N. Bose	84
19.	Stream lines of laminar and turbulent "Grenzschicht." By N. K. Bose	85
20.	Generation of Karman's vortex-path. By N. K. Bose ..	85
21.	Variation of lift of a bi-plane with the angle of attack. By N. K. Bose	85
22.	Waves in horizontal canals. By B. M. Sen	85
23.	Waves in basins. By B. M. Sen	86
24.	Hydrodynamical problems connected with turbulent flow in earthern channels. By B. H. Wildson	87
25.	A factorable continuant. By S. Ch. Chakrabarti ..	87
26.	A note on the simplification of persymmetric determinants. By M. V. Ayyer	89
27.	On the co-efficients in a certain trigonometric expansion. By M. V. Ayyar and M. B. Rao	90
28.	Evaluation of special persymmetrics—Part III. By M. B. Rao and M. V. Ayyar	91
29.	A special cubic curve. By M. V. Ayyar	93
30.	The Bakshali manuscript. By A. A. K. Ayyangar ..	93
31.	The Josephus problem and its extension. By A. A. K. Ayyangar	94
32.	On a perspective-criterion for the double contact of two conics. By A. A. K. Ayyangar	94

		Page
33.	On mutually self-polar triangles. By C. V. H. Rao ..	94
34.	Experimental harmonic motions; coupled oscillations Part II. By S. G. Subrahmanyam	95
35.	Projection of spectra:—Part III. By S. G. Subrahmanyam	95
36.	The effect of the dielectric constant on the adsorbability of ions (Part I). By J. N. Mukherjee and S. G. Choudhury	95
37.	On the stress and strain in an elastic plate having two infinitely long straight edges under the action of a couple at the corner. By N. M. Basu and H. M. Sen Gupta	95
38.	The resistance of a nickel wire beyond the elastic limits. By Chetan Anand and Dina Nath	95
39.	A Poisson's ratio tester. By Durgadas Bannerji ..	96
40.	On the possibility of the fundamental magnitudes of the second order of a surface being expressed seperately in terms of those of the first order and their derivatives. By Harendranath Datta	96
41.	On a problem of rolling motion. By H. Datta ..	96
42.	Efficiency of musical instruments. By R. N. Ghosh and B. Majumdar	97
43.	Acoustics of the pianoforte. By R. N. Ghosh ..	97
44.	On the solution of two problems of central orbits, by the method of rectors. By K. Khastgir	97
45.	Geometrical interpretation of the invariants of a pair of bilinear forms. By A. N. Rao	98
46.	Fine structure of spectrum lines. By W. Mohammad and S. B. L. Mathur	98
47.	A note on Quincke's method of finding the surface tension. By T. P. Gaurgas	98
48.	A note on the variation of pitch with amplitude. By W. Chowfin	98
49.	On the nature of discharge through a neon tube. By B. P. Srivastava and K. Gopal	99
50.	Change of wave-length by transmission through a thickness of transparent glass. By S. Ray	99
51.	On the possible spurious character of the "fine structure" of lines and of the "continuous spectrum" of hydrogen, etc. By S. Ray	99
52.	Oscillations of audible frequency produced in a neon lamp. By G. R. Paranjpe	100
53.	Use of carbonic acid gas in mercury interrupters. By G. R. Paranjpe and H. D. Tendulkar	100
54	On the origin of the movements of camphor on water and other allied phenomena. By L. A. Ramdas ..	100
55.	Some measurements of the ellipticity of light reflected at the free surface of liquids at the brewsterian angle. By L. A. Ramdas	101
56.	The scattering of light by gaseous mixture at high pressures. By L. A. Ramdas	101

PAGE

57. The Barkla-effect with scattered x-radiation (the J-phenomenon). By S. R. Khastgir 101
58. The action of magnetic field on the refractive index of carbon dioxide gas. By P. N. Ghosh and P. C. Mahanti 102
59. Convergence of certain multiple series and integrals. By K. S. K. Iyenger 103
60. Predetermination of the voltage distribution on a string of suspension insulators. By G. Yoganandan .. 104

Section of Chemistry.

Presidental Address. By Prof. H. K. Sen, M.A., D.I.C., D.Sc. 105

Papers.

1. A preliminary note on the ignition points of Sulphur and Phosphorus. By N. M. Shah and R. L. Alimchandani 130
2. Compounds of hydrazine with metallic sulphites and nitrites. By P. R. Rây and B. K. Goswami .. 130
3. The constitution of infusible and fusible white precipitates of mercury. By P. R. Rây and P. C. Banerjee 130
4. A new series of double sulphates of the copper magnesium group and the sulphonium bases. By P. C. Rây and N. N. Ray 131
5. The action of a solution of bromine in carbon-tetrachloride on strontium-hydroxide-octahydrate. By K. Lal, H. Das and H. B. Dunnicliff 131
6. The determination of the equivalent weights of mercurry, magnesium, tin and aluminium by the synthesis of their bromides. By B. Singh and H. B. Dunnicliff .. 132
7. The action of alkaline ferricyanide on silver nitrate solution and the constitution of silver peroxide. By P. N. Dasgupta and P. R. Rây 132
8. Varying valency of gold. Part II. Inadequacy of Werner's theory. By P. Rây and K. C. Bose-Rây .. 132
9. Varying valency of platinum. Part V. The inadequacy of Werner's theory to explain certain anomalous cases. By P. C. Rây and K. C. Bose-Rây 132
10. Action of rubeanic acid upon sodium cobaltinitrite and the formation of a cobaltic rubeanate. By P. R. Rây and A. K. Chattopadhya 133
11. Action of hexamethylene tetramine upon solutions of salts of the elements of Group III and a new method for the quantitative separation of iron from manganese, zinc, nickel and cobalt. By P. R. Rây and A. K. Chattopadhya 133
12. A note on the determination of mixture of thiosulphates and sulphites. By C. L. Soni and H. B. Dunnicliff .. 133
13. The titration of acids by a solution of sodium hydrogen phosphate. By N. M. Shah and R. L. Alimchandani 134
14. The titration of acids by a solution of sodium borate. By A. N. Meldrum and S. M. Mehta 134

		Page
15.	Estimation of halides in a mixture. By Q. A. Mansuri..	134
16.	Complex salts derived from p-nitrosodimethyl aniline and metallic chlorides. By I. Sen Gupta ..	134
17.	Action of hydrogen sulphide on lead peroxide. By G. Sambamurti	134
18.	Catalytic oxidation of water. By M. Goswami ..	135
19.	Smith-Stoner's classification of electron subgroups and the co-valency conception as applied to simple and co-ordination compounds. By P. R. Rây	135
20.	The system $(NH_4)_2$ $SO_4-H_2SO_4-C_2H_5OH$. By H. B. Dunnicliff, A. L. Aggarwal and R. C. Hoon ..	135
21.	Activity of cadmium sulphide in presence of neutral chlorides. By S. Krishnamurti	136
22.	The indices of refraction of some organic crystals and of inorganic salts in aqueous solution. By S. S. Bhatnagar and S. L. Bhatia.	136
23.	The relation between atomic structure of salts and the physical properties of their solutions.—Part I: Viscosity and surface tension. By R. K. Asundi ..	136
24.	On the application of kinetic theory to surface films. By K. C. Sen	137
25.	Experimental contribution to the theory of equation of state for adsorbed substances. By H. L. Roy ...	137
26.	Effect of impurities on the intensity and colour of phosphorescence of calcium sulphide. By. S. S. Bhatnagar, N. A. Yajnik and N. Singh	137
27.	Surface reflectivity of liquids. By. S. S. Bhatnagar, N. A. Yajnik and N. G. Mitra	138
28.	Some observations on the factors governing the hygroscopicity of aqueous crystals. By S. S. Bhatnagar, N. A. Yajnik and P. Chandra	138
29.	Theories of the formation of periodic precipitates: II. By A. C. Chatterjee	138
30.	On the formation of periodic precipitates: V. By A. C. Chatterjee	139
31.	Peptising influence of gels on sparingly soluble substances and its importance in the formation of Liesegang rings. By A. C. Chatterjee.	139
32.	Adsorption of colloidal solutions and of ions by freshly prepared precipitates. II. By A. C. Chatterjee ..	140
33.	Effect of time on the gelating sols. By S. S. Bhatnagar, N. A. Yajnik and D. Raj	140
34.	Chromatic emulsions. By S. S. Bhatnagar, N. A. Yajnik and I. Dass Bhalla	140
35.	Studies in photo-sols. Part I. By S. S. Bhattnagar, N. A. Yajnik and V. D. Zadoo.	141
36.	Vicosity of sodium and potassium amalgams. By M. Prasad and S. D. Bhave	141
37.	Hydrolysis of ammonium carbonate solutions. By. C. J. J. Fox and C. L. Mankodi	141

		Page
38.	Change of electric conductivity of hydrophobe and hydrophile colloids on ageing. By N. R. Dhar ..	142
39.	Some special features of organo-sols. By S. S. Bhatnagar and S. L. Bhatia	142
40.	Vicosity of sols in presence of electrolytes. By D. N. Chakravarti	142
41.	The effect of non-electrolytes on the coagulation of ferric hydroxide sol. By S. G. Choudhury and A. T. Ganguli	142
42.	The effect of dilution and of non-electrolytes on the coagulation of colloids. By S. G. Choudhury and N. Chatterjee	143
43.	On the independent activity of ions and on the annulment of the junction potential by saturated solution of potassium chloride. By J. N. Mukherjee and K. K. Kumar	143
44.	The partition coefficient of organic acids between benzene and water as affected by neutral electrolytes. By J. N. Mukherjee and R. P. Mitter ..	143
45.	The effect of direct and alternating current electrolysis on adsorbed substances. By S. S. Bhatnagar and S. L. Bhatia	143
46.	On the nature of hydrolytic adsorption. Part II. Silver salts. By J. N. Mukherjee and J. K. Basu ..	144
47.	Measurement of charge with mixtures of electrolytes. By J. N. Mukherjee and S. R. Choudhury ..	144
48.	Adsorption and coagulation of stannic hydroxide sol. By S. Ghosh.	144
49.	Photochemical decomposition of ferricchloride in alcoholic solutions. By K. D. Nigudkar	145
50.	Further investigations on the photobromination of tartaric acid. By J. C. Ghosh and K. Bose ..	145
51.	Absorption of light in the ultraviolet by organic acids in presence of uranyl salts. By J. C. Ghosh and J. Mukherjee	145
52.	Further investigations on the photobromination of cinnamic acid and stilbene. By J. C. Ghosh and R. M. Purkayastha	146
53.	Systems formed by water and reciprocal salt pairs. Part I. Phase reactions at the invariant points. By M. A. Hamid	146
54.	Systems formed by water and reciprocal salt pairs. Part II. The identification of solid phases. By M. A Hamid	147
*55.	Period of induction in chemical reactions. Part I: Interaction of mercuric chloride and sodium bicarbonate. By P. Neogi and S. Neogi	147
56.	Studies in interfacial tension. By D. N. Ghosh and H. E. Watson	147
57.	The photochemical oxidation of toluene and benzaldehyde. By C. J. Kothari and H. E. Watson ..	147

		Page
105.	Hydrogenation of "Nag-kesar" (*Mesua ferrea*) oil. By G. K. Mukherjee	163
106.	Preparation of 4-acetylamino-3-chloro-phenyl stibinate of sodium. By S. C. Niyogy	163
107.	Gas volumetric estimation of -SOOH in sulphinic acids. By S. Krishna and B. Dass	164
108.	Estimation of -SOOH and Fe″′. By S. Krishna and H. Singh	164
109.	Acetylation of diamine. By K. H. Hasan	164
110.	The effect of dyes and the various processes of dyeing on the lustre of silk fabrics. By S. S. Bhatnagar, N. A. Yajnik and N. N. Sarin	164
111.	Studies in invertase. Part I. By B. N. Sastri and Roland V. Norris	165
112.	A simple method for concentrating enzyme solutions. By B. N. Sastri	165
113.	Studies in the proteins of Indian grains. Part I. Ragi (*Eleusine coracana*). By N. Narayan and Roland V. Norris	165
114.	Urease content of seeds of several Indian plants. By P. B. Sen	165
115.	Some physical properties of urease and method of obtaining it in purer form. By P. B. Sen	165
116.	A microchemical method for locating urease within cell By P. B. Sen	166
117.	Studies on amylase from *Andropogom sorghum*, Part I. By V. N. Patwardhan and Roland V. Norris ..	166
118.	Studies on amylase from *Andropogom sorghum*, Part II. By V. N. Patwardhan and Roland V. Norris ..	166
119.	Cyclohexeneoxide and its hydrolysis by yeast. By H. K. Sen and C. R. Barat	167
120.	The estimation of iodine in soils. By D. A. Rama Rao and Roland V. Norris	167
121.	The sedimentation method of mechanical analysis of soils. By Rao Sahib M. R. Ramaswami Sivan ..	167
122.	Cyclic processes involved in the manufacture of sodium nitrate from Chilean caliche. By M. A. Hamid ..	167
123.	Principles governing the application of manures to paddy and the determination of assimilation factors. By Rao Sahib M. R. Ramaswami Sivan ..	168
124.	Extraction of papain from papaya. By H. D. Sen and E. R. Watson	168
125.	Castor cake fodder. By H. M. Mulany and G. J. Fowler	168
126.	A rapid method of detecting adulteration in ghee. By D. Y. Athawale	168
127.	Attempts to prepare citral, geraniol or similar open chain turpenes or menthol from turpentine, especially from Indian turpentine. By H. M. Mulany and E. R. Watson	169
128.	Cymene from ajwan oil. By S. R. Bhate and Khwaja H. Hasan	169

PAGE

129. Storage of 'Mohwa' flowers. By S. R. Bhate and Khwaja H. Hasan 169

130. Study on the formation of pure tricalcium sucrate. By E. R. Watson, K. C. Mukerjee and H. S. Chaturvedi .. 169

131. Formation of quinicine during sterilisation of quinine hydrochloride. By Khwaja H. Hasan 170

132. Quick method of determining adulteration in Madras bark-tanned skins and hides. By K. S. Choudary, A. Guthrie and E. Yoganandam 170

133. Studies in 'Avaram' bark. By K. S. Choudary and E. Yoganandam 170

134. Effect of neutral salts on the basicity of chrome liquors. By B. B. Dhavale and B. N. Pal 171

135. Correction of lactometer readings for temperature. By Rao Sahib M. R. Ramaswami Sivan 171

136. On the nature of Kohlschütter's silver sol. By P. S. MacMahon and M. R. Nayar 171

137. Dilatometric investigations of enzyme action. By M. Sreenivasaya 171

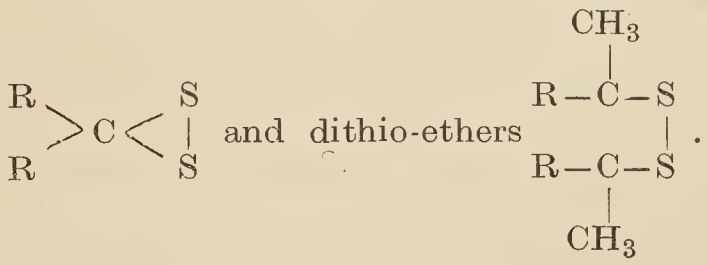
138. Enzymes of the lac insect with special reference to carboxylase. By M. Sreenivasaya 172

139. Interaction of sulphur dichloride with substances containing the reactive methylene ($-CH_2-$) group. By K. G. Naik and G. V. Jadhav 172

140. Interaction of sulphur monochloride with substances containing the reactive methylene group, ($-CN.\ CH_2.\ CO-$). By K. G. Naik and Y. N. Bhat .. 173

141 Condensation of cyanacetic ester with some aryl and alkyl amines. Preparation of some aryl and alkyl substitutedcyan-acetamides. By K. G. Naik and Y. N. Bhat 173

142. Interaction of sulphur monochloride with organic compounds containing the reactive methylene ($-CH_2-$) group. Formation and properties of dithio-ketones



and dithio-ethers

By K. G. Naik and V. N. Bhat 174

143. Influence of light on certain catalytic reactions. By N. C. Nag 174

Section of Zoology.

Presidential Address: The study of zoology in India in the future. By Major R. B. S. Sewell, M.A., M.R.C.S., L.R.C.P., F.A.S.B., F.L.S., F.Z.S., I.M.S. .. 177

Papers.

1. *Tetrachilomastix bengalensis* Chatterjee, a different species or the same as *Chilomastix mesnili* Wenyon. By G. C. Chatterjee, H. N. Roy and A. N. Mitra 188

		Page
2.	An account of the intestinal flagellates. By H. N. Roy	188
3.	On some parasitic ciliates from indian frogs, toads, earthworms and cockroaches. By B. L. Bhatia and A. N. Gulati	188
4.	Four new species of *Epistylis* Ehr. By E. N. Ghosh ..	189
5.	Some further observations on the monocystids of the oligochaetes and polychaetes. By S. B. Setna ..	189
6.	On some fresh-water rhizopods and flagellates from Kashmir. By B. L. Bhatia	189
7.	Parasitism among protozoa. By B. L. Bhatia ..	189
8.	Preliminary notes on *Ctenoplana indica* n. sp By K. R. Menon	190
9.	On the systematic position of the actiniarian genus *Ixalactis*. By K. R. Menon	190
10.	A note on the *Hydra* of the Bombay Island. By P. R. Awati	190
11.	Some jelly-fishes of the Indian seas. By H. S. Rao ..	190
12.	Three new trematodes from reptiles. By G. D. Bhalerao	191
13.	The trematode parasites of a Burmese house-crow, *Corvus insolens*. By G. D. Bhalerao	191
14.	Re-description of *Caryophyllaeus indicus*. By M. A. Moghe	192
15.	A preliminary note on helminth parasites of *Ophiocephalus*. Trematodes and cestodes. By S. C. Verma	193
16.	Observations of a pigeon heavily infested with tape worms. By G. Sondhi	193
17.	*Acanthogyrus*, a new genus of acanthocephalan worm, from the intestine of *Labeo rohita*. By G. S. Thapar..	194
18.	On *Echinorhynchus* sp. from the common crow (*Corvus corax* and *Corvus splendens*). By M. N. Datta ..	194
19.	Observations on the reproduction of the Naididæ with certain facts of geographical distribution of the Indian Microdrili. By H. R. Mehra	195
20.	Suction of air by *Chaetogaster orientalis* as a means of locomotion. By H. R. Mehra	195
21.	The reproductive processes of the earthworm *Eutyphoeus waltoni*. By K. N. Bahl	195
22.	A note on the development of *Ostrea cucullata*. By P. R. Awati and H. Rai	195
23.	A preliminary report on the anatomy and life history of the common edible back-water oyster, *Ostrea madrasensis*. By S. T. Moses	196
24.	A note on the development of *Oncis martensi*. By P. R. Awati and K. R. Karandikar	196
25.	Observations on the breeding habits and fecundity of *Limnaea luteola* Lamarck, forma *typica*. By R. V. Seshaiya	196
26.	Note on two species of hibernating gastropod molluscs from the Kangra Valley. By H. S. Rao	197
27.	On two species of fresh-water polyzoa from Lahore. By Ch. A. Hamid	197

PAGE

28. On the fresh-water Entomostraca of Lahore. By G. L. Arora 198

29. Influence of moist surface on oviposition response of *Aulacophora abdominalis* Fb. (Coleop.) and *Dysdercus cingulatus* Fb. (rhynchota). By M. Afzal Hussain .. 198

30. On the external morphology and anatomy of a new species of Embiadine with special reference to the spinning organs and its habitat. By S. Mukerjee 198

31. On a new species of *Oligotoma* from Peradenyia (Ceylon). By H. N. Ray 198

32. The function of anterior tibial spurs in *Amsacta albistriga*. By Y. R. Rao 199

33. On the emergence of mayfly swarms. By S. L. Hora .. 199

34. The origin of yolk in certain ova.

(*a*) In the eggs of spiders. By Vishwa Nath .. 200

(*b*) In the eggs of *Luciola gorhami*. By Vishwa Nath and D. R. Mehta 200

(*c*) In the eggs of *Scolopendra*. By Vishwa Nath and Tasdique Husain 201

35. Some observations on the life-history of *Luciola gorhami*, (Lahore fire-fly). By D. R. Mehta 201

36. Preliminary observations on some South Indian Acarina. By M. C. Cherian 202

37. A study of indian ticks of the family Ixodidae with special reference to mouth-parts. By M. Sharif .. 202

38. An ant-like spider of the genus *Synemosyna* Hentz, from Barrackpore, Bengal. By D. Mukerji .. 202

39. The circulation of mixed blood through the heart of *Ophiocephalus punctatus* bloch. By S. H. Lele .. 203

40. Early stages in the development of gold fish. By Hamid Khan 203

41. Remarkable vitality of fish. By Hamid Khan .. 204

42. The manuscript drawings of fish in the library of the Asiatic Society of Bengal. By S. L. Hora .. 204

43. On some frogs and toads from the Punjab. By C. L. Sawhney 204

44. On the occurrence of *Rana afghana* in the Western Himalayas. By S. L. Hora 205

45. Little noticed habits of some birds of the district of 24-Parganas. By S. C. Law 205

46. Notes on the fauna of the Bombay shore. By P. R. Awati, K. R. Karandikar and H. Rai .. 206

47. Preliminary observations on the fauna of the Kangra Valley. By S. L. Hora 207

Section of Botany.

*Presidential Address. By Prof. M. A. Sampathkumaran, M.A., Ph.D. 209

Papers.

		Page
1.	Algal flora of the Chilka-Lake, Ganjam District, Madras Presidency. By Kalipada Biswas ..	209
2.	On a new genus of the Scytonemataceæ. By Y. Bharadwaja	209
3.	The sub-aerial blue-green algæ of Rangoon. By S. L. Ghose	209
4.	Characeæ of Bombay and Salsette Islands. By S. C. Dixit	210
5.	Three species of Debarya from South India. By M. O. Parthasarathy Iyengar	210
6.	Studies on the root nodule organism of the leguminous plants. By P. L. Anand	210
7.	Studies in the biological and cultural characters of Capnodium on cotton. By A. Sawhney	211
8.	The 'blast' disease of rice and its control. By S. Sundararaman and K. M. Thomas	211
9.	Observations on *Thielaviopsis paradoxa*. By T. S. Ramakrishnan	212
10.	Some observations on varietal resistance to 'rust' of coffee. By K. M. Thomas	212
11.	Gummosis of citrus trees in the Bombay Presidency. By M. N. Kamat	213
12.	Gall formation on the roots of mustard due to a smut (*Urocystis corraloides* rostrup). By M. Mitra ..	213
13.	Fruit-rot disease of cultivated cucurbitaceæ caused by *Pythium aphanidermatum* (Eds.) Fits. By M. Mitra ..	213
14.	A note on the morphological characters of two physiological species of *Puccinia graminis* Pers. By K. C. Mehta	214
15.	A preliminary note on the infection histology of two "physiological species" of *Puccinia graminis* Pers. By K. C. Mehta	214
16.	A note on the infection histology of *Puccinia triticina* (dispersa) Eriks and Honn. By K. C. Mehta ..	214
17.	Notes on *Riccia robusta* Kashyap. By S. K. Pande .	214
18.	Notes on morphology and the development of the sporophyte of *Notothylas indica* Kashyap. By S. K. Pande	215
19.	The comparative anatomy of *Ophioglossum Aitchisoni* D'Almeida; and *Ophioglossum vulgatum* L. By B. R. Vasisht	215
20.	Male flowers and microsporogenesis in *Pinus longifolia*. By M. L. Sethi	215
21.	On the occurrence of the funnel-like leaves (ascidia) in *Ginkgo biloba*. By B. Sahni	215
22.	On some petrified cones of Indian fossil conifers from the British Museum, London. By B. Sahni ..	215
23.	Replacement of fertile shoots by vegetative shoots in *Euphorbia tibetica* boiss. By S. R. Kashyap ..	216
24.	Apocarpy in a cultivated variety of *Solanum melongena*. By C. M. John	216

		Page
25.	The medullary bundles in *Achryanthes aspera* Linn. By P. M. Somasundaram	216
26.	On the morphology of the flowers and the embryology of *Vallisneria spiralis* L. By K. Rangasamy ..	216
27.	Origin and nature of the shoot-axis (stem) and the primary root. By G. P. Majumdar	216
28.	Anatomical and physiological investigations on two species of Mimosa. By P. L. Anand	217
29.	The exudation of mucilage by adventitious aerial roots of *Sorghum vulgare*. By K. Venkataraman ..	217
30.	On the physiology of potato tubers. By J. C. Luthra and B. L. Batra	218
31.	Respiration of ripening ricinus fruits. By P. Parija ..	218
32.	Relations between water content and the rate of photosynthesis with an increased supply of carbon dioxide. By R. H. Dastur and R. E. Cooper	218
33.	On the nyctitropic movements exhibited by the cotyledons of *Cassia tora*. By N. K. Tiwary	219
34.	On the behaviour of the radicle and plumule of species of Eugenia during germination, and its probable significance. By N. K. Tiwary	219
35.	Experimental researches on the growth of tropical plants. Part I. By B. N. Singh and V. V. Apte ..	219
36.	Experimental researches on the growth of tropical plants. Part II. By B. N. Singh and V. V. Apte ..	220
37.	Ontogenetic drifts in the photosynthetic activity of the foliage leaves of the radish plant. By B. N. Singh and Krishna Kumar	220
38.	Researches on the chemistry and physiology of tropical plants. Part I: A critical study of the carbohydrate analysis in plant organs. By B. N. Singh, T. S. N. Singh and Balwant Singh	220
39.	Part II: The rôle of the carbohydrate-nitrogen balance throughout the ontogeny of the radish plant. By B. N. Singh, T. S. N. Singh, and Balwant Singh ..	221
40.	The influence of light and darkness upon growth, development and reproduction in *Vicia faba*, *Avena sativa*, and *Helianthus annus*. By H. Chaudhuri ..	221
41.	Chlorophyll from Indian plants. The relation between the chlorophyll content and water content in leaves in different stages of growth. By R. H. Dastur and N. A. Buhariwalla	222
42.	Determination of the effect of season on the growth of the rice crop at Karjat. By R. K. Bhide ..	222
43.	The influence of definite doses of sugar on respiration of leaves. By Shri Ranjan	223
44.	The root habits of a xerophytic plant community. By P. M. Somasundram	223
45.	The aquatic vegetation of Bengal, in relation to supply of oxygen to water. By Kalipada Biswas ..	223
46.	The *Shorea robusta* forest of Bhowal in Dacca. By H. K. Datta	224

PAGE

47. A short note on parthenogenesis in cotton. By R. Balasubrahmanyam 224

48. The inheritance of purple pigmentation in *Eleusine coracana*. By G. N. R. Ayyangar and P. Krishna Rao .. 224

49. The science of botany in ancient India. By G. P. Majumdar 224

50. An improved type of cotton for Khandesh. By S. H. Prayag 225

Section of Geology.

Presidential Address: The oil fields of Burma: Recent advances in geological knowledge. By L. Dudley Stamp, B.A., D.Sc., A.K.C., F.G.S., F.R.G.S., A.M.I.P.T. 227

Papers.

1. On two types of fossil wood from the Utatur Cretaceous, Trichinopoly District. By K. M. Ahmed .. 237

2. On a new type of Cassidulidæ from the Upper Cretaceous rocks near Ariyalur. By S. L. Rao 237

3. Stigmatopygus vs. Cyrtoma, a discussion in nomenclature. By L. Rama Rao 237

4. Kyanite from Nellore. By V. S. Swaminathan .. 237

5. Notes on the mode of occurrence and composition of beryl from Nellore. By V. S. Swaminathan .. 238

6. Petrological notes on (*a*) granitic and gneissic rocks, and (6) quartz-augite-porphyrite from Nellore, Madras. By V. S. Swaminathan 238

7. The rhyolites and rhyolite tuffs of Thaton District, Lower Burma. By H. L. Chhibber 239

8. The serpentines and the associated minerals of Hengada and Bassein Districts. Burma. By H. L. Chhibber.. 239

9. The petrography of some of the indian and burmese slags. By H. L. Chhibber 240

10. The ancient volcanoes of Burma. By H. L. Chhibber .. 240

11. Three deep-sea deposits from the Bay of Bengal. By N. N. Chatterji 240

12. Fossil wood from the Lalmai Range in Comillah. By J. Sen 240

13. Batrachian and reptilian remains found in the Panchet Beds at Deoli, Bengal. By H. C. Das-Gupta .. 240

14. Notes on the geology of the Island of Bombay. By H. C. Das-Gupta 240

15. The Punjab Government hydro-electric power station at Mandi and its bearing on the mineral resources of the Mandi State. By S. K. Roy 241

*10. The age of the so-called danian fauna from Tibet. By G. DE. P. COTTER 241

*17. The distribution of the gault in India. By G. DE. P. COTTER 241

PAGE

18. On the discovery of an Indian species of Blanckenhorn's genus *Dictyoconus*. By L. M. Davies 241

Section of Medical and Veterinary Research.

Presidential Address: Some aspects of therapeutics in India. By Major R. N. Chopra, M.A., M.D., I.M.S. .. 243

Papers.

1. Evolution of a strain of vaccinia virus from the virus of contagious epithelioma of fowls. By C. G. Pandit.. 262

2. Classification of lactose-fermenters by serological methods. By T. S. Iyer 262

*3. A short note on three different varieties of fungous growths isolated from cases of mycetoma that were admitted for treatment in the Madras General Hospital. By T. S. Iyer 262

*4. A short note on a yeast-like growth isolated from a case of rhinosporidium. By T. S. Iyer 263

5. Some observations on the treatment of climatic bubo by protein shock. By G. H. Dive and P. N. Basu .. 263

6. Some observations on cases of anaemia and sprue in Bombay. By P. N. Basu 263

7. Tumours caused by intraperitoneal inoculation of *B. lepra murium*. By E. Muir, J. M. Henderson and E. Landeman 264

8. Some observations on the administration of calcium in chronic broncho-pneumonic phthisis. By P. N. Suri 264

9. Application of our knowledge of tuberculosis to Indian conditions. By C. Frimodt-Moller 264

10. Sanocrysin treatment of tuberculosis, with special reference to Indian patients. By C. Frimodt-Moller .. 265

11. The value of the complement fixation test in the diagnosis of tuberculosis, with special reference to its relation to the tuberculin reaction. By M. K. Pai and K. V. Rau 265

12. The incidence and types of tuberculosis met with in India. By A. C. Ukil 266

13. On certain aspects of artificial pneumothorax therapy in India. By M. K. Pai 266

14. The scope of collapse therapy (artificial pneumothorax and thoracoplasty) in the treatment of pulmonary tuberculosis in India. By P. T. Patel .. 266

15. Use of fishes for control of mosquitoes. By S. L. Hora 266

16. Physiology of the coronary circulation. By E. W. H. Cruickshank 267

17. A preliminary note on anaerobic infections in India. By A. C. Ukil 267

18. The absence of specific agglutinins in the blood of healthy carriers of Koch's vibrio. By J. W. Tomb and G. C. Maitra 268

		Page
19.	A new conception of the origin of cholera epidemics. By J. W. Tomb and G. C. Maitra	268
20.	A preliminary note on the treatment of cholera at the Puri cholera hospital by the serum of convalescent patients. By P. N. Das and S. C. Basu	269
21.	The role of certain Gram-negative non-lactose-fermenting Bacilli in the causation of bacillary dysentery in Bengal. By A. A. Ukil and A. K. Sen	269
22.	The action of tropical sunlight on bacteria. By A. C. Ukil and M. M. Basu	269
23.	The action of certain antiseptics on bacteria. By A. C. Ukil and M. M. Basu	270
24.	A plea for a thorough investigation on the Filariasis problem. By Sir Frank Connor	270
25.	Some points in connection with maternity and child welfare. By H. G. Stiles-Webb	270
26.	A silver method of staining Leishman-Donovan bodies in the tissues. By C. C. Bose	270
27.	On the adsorption of chemical elements by bacterial bodies. By N. Banerjee and J. K. Basu ..	270
28.	Ferro-solvency of drinking waters. By V. G. Raju ..	271
29.	Bacteriological efficiency of mechanical gravity filters for purification of water. By V. G. Raju ..	271
30.	Germicidal power of ethyl alcohol in spirits. By B. B. Brahmachari	271
31.	Food value of the nut of *Trapa bispinosa*. By B. B. Brahmachari and N. K. Chatterjee	272
32.	*Psoralia corylifolia* (babchi). Its chemical composition, pharmacological action and therapeutic properties. By R. N. Chopra and N. R. Chatterjee ..	272
33.	Observations on the chemical composition, pharmacological action and therapeutic properties of *Saussurea lappa*-kuth root. By R. N. Chopra, S. Ghosh, P. De, and A. T. Dutt	272
34.	Toxicity of mature and immature genuine spirits and imitation or factitious spirits. By R. N. Chopra ..	273
35.	The causation of production of cystitis. By G. Panja and K. Banerjee	273
36.	A few important facts regarding manufacture of soda-water from the chalk-derived water of a deep tube well. By N. L. Banerjee	273
37.	A new method of determining temperature of small insects. By H. W. Acton and S. K. Mazumdar ..	274
38.	Relationship of the colour of rabbits to their susceptibility to insulin. By W. H. Acton and J. P. Bose ..	274
39.	Production of oriental sore in man by flagellate culture of *Leishmania tropica*. By Ganapati Panja ..	275
40.	Observations on the tuberculin test, with special reference to the intradermo-palpebral tests conducted with the ordinary concentrated tuberculin and concentrated avian tuberculin for the detection of tuberculosis and Johne's disease in cattle. By V. K. Ayyar	275

		Page
41.	A note on the occurrence of carcinoma among cattle in the Madras Presidency. By V. K. Ayyar ..	276
42.	A note on the incidence of tuberculosis among cattle of Madras Corporation and their susceptilibity to tuberculosis. By V. K. Ayyar	276
43.	Sarcoids or acquired angeiomata. By H. W. Action ..	277
44.	The causation of epidemic dropsy. By H. W. Acton and R. N. Chopra	277
45.	Puerperal sepsis. By C. A. F. Hingston and A. Lakshmanaswamy	277
46.	Puerperal eclampsia. By C. A. F. Hingston and A. Lakshmanaswamy	278
47.	Tropical neurasthenia. By H. W. Acton	278
48.	The primary investigation into the cause and aetiology of filarial lymphatic obstruction. By H. W. Acton and S. Sunder Rao	279
*49.	Biochemical reaction of the organism of bovine lymphangitis. By V. K. Ayyar	279
50.	Globulins in kala-azar and syphilis. By C. B. Ray ..	279
51.	A preliminary note on the pharmacological action of concessine, the alkaloid of *Holarrhena antidysenterica*. By R. N. Chopra, J. C. Gupta, J. C. David and N. N. Ghosh	280
52.	Effect of injections of unsaturated fatty acids on chyluria and lymphorrhagia of filarial origin. By K. K. Chatterjee	280
53.	Observation on the pathology of amoebiasis. By K. K. Chatterjee	280
54.	A simplified cold incubator keeping a temperature of 22°C.—25°C. By A. C. Ukil	281
55.	On the action of cobra-venom on Heart. By N. M. Basu	281
56.	Some observations on the treatment of asthma. By H. Ghosh	281
57.	On the increase of mortality due to tuberculosis in this country by massive infection. By G. C. Chatterjee ..	282
58.	Some factors which influence the incidence of leprosy. By E. Muir	282
59.	Constants of pure cow ghee. By B. B. Brahmachari ..	282
60.	The distribution of hymenolepis infections in India with a discussion of its epidemiological significance. By Asa C. Chandler	282
*61.	The chemotherapy and surra (*Trypanosoma evansi* infections) of horses and cattle. By J. T. Edwards ..	283
*62.	A new species of *Dipyledium*, Leuckart, 1863, from a Siamese Cat. By A. Gulari	283
*63.	The chemotherapy of trypanosomiasis, with special reference to surra. By S. K. Sen	283
*64.	Opium addiction. By R. N. Chopra and K. S. Grewal..	283

Section of Anthropology.

PAGE

Presidential Address: Anthropology and administration. By J. H. Hutton, Esq., M.A., D.Sc., I.C.S., C.I.E. 285

Papers.

1. The bull roarer in India. By Rai Bahadur S. C. Roy .. 300
2. On a peculiar fishing implement from the Kangra Valley. By S. L. Hora 300
3. Some objects of anthropology. By J. P. Mills .. 300
4. Sectarian marks of Hindus in South India. By Rai Bahadur L. K. A. Iyer 300
5. Totemism in South India, with special reference to Mysore. By Rai Bahadur L. K. A. Iyer .. 301
6. Polyandry in the Mahabharata. By H. C. Das-Gupta .. 301
7. Untouchables among animals and plants. By Rai Bahadur Hiralal 301
8. The tortoise in Indian life and religion. By S. T. Moses 301
9. The sanctity of hair in South India. By S. T. Moses .. 301
10. The calendar of the Angami Nagas. By J. E. Tanquist 302
11. On the cult of Gorakshanātha in the district of Rangpur in Northern Bengal. By S. C. Mitra 302
12. A Rangpuri superstition. By S. C. Mitra 302
13. Note on the use of ferns as an article of food in the district of Rangpur in Northern Bengal. By S. C. Mitra 303
14. Note on the legends about the origin of the place-name Rangpur. By S. C. Mitra 303
15. A Satya Pīr legend in Santali guise. By S. C. Mitra .. 304
16. Further note on human sacrifice among the Santals. By S. C. Mitra 304
17. Note on a recent instance of self-immolation for propitiating a god. By S. C. Mitra 304
18. The indian folk-belief about the corpse's eating the winding-sheet in which it is swathed. By S. C. Mitra .. 305
19. Notes on the three Bengali women's charms for stopping storms. By S. C. Mitra 305
20. The Poo-Nonbu in Kongu Nad. By P. M. Somasundaram 306
21. Some popular beliefs in the lunar periodicity in animals and plants. By P. M. Somasundaram 306
22. Naga medicine. By H. G. Dennehy 306
23. The *Kani* (opium) *Puja* of the Mikirs of Assam. By H. G. Dennehy 306
24. The frog marriage in Assam. By T. C. Saikia .. 306
25. Palæolithic evolution in India. By L. A. Cammiade .. 306
26. A comparative study of the human crania excavated at Adittanallur. By B. S. Guha 307

PAGE

27. The matrimonial Institutions of the Syntengs. By B. S. Guha 307
28. A comparative study of some measurements of the Hos. By A. N. Chatterjee 307
29. A statistical study of some measurements of the Varendra Brahmins of Bengal. By T. C. Roy Chaudhuri .. 307
30. Terms of relationship of the Hos of Seraikella. By T. C. Das 307
31. Social organization of the Hos of Seraikela. By T. C. Das 307
32. Stone implements from the Seraikela State. By Panchanan Mitra 307
33. Iron slags from the Seraikela State. By Panchanan Mitra 308
34. Ho hut designs. By Panchanan Mitra 308

Section of Psychology.

Presidential Address. By Lt.-Col. Owen A. R. Berkeley Hill, M.D., I.M.S. 309

Papers.

1. A dream of an ascetic disciple. By S. L. Sarkar .. 319
2. On the love of music. By T. H. Thomas 319
3. Studies in Psychodynamics. Applications in Criminal Law. By S. S. Menon 319
4. Echoes of a psychology of dreams in Upanishads. By R. N. Sarma 320
5. The place of consciousness in mental Life. By P. B. Adhikari 320
6. The Behaviorist standpoint. By K. S. Ghosh .. 321
7. Interpretation of insane conduct. By F. Noronha .. 321
8. Inferiority complex. By H. D. Bhattacharyya .. 322
9. The combination of speed and quality in Bengali handwriting. By J. C. Dutt and D. N. Sarkar .. 322
10. The choice of future profession of 1,013 Bengali boys. By S. K. Banerjee and H. C. Mukerjee .. 322
11. The superstitions of Bengali teachers. By Ainul Quari 322
12. The effect of knowledge of the purpose in the marking of compositions. By A. K. Datta 322
13. The reliability of essay marks. By A. K. Datta .. 323
14. Psychology and the school text-book. By Michael West 323
15. Error in the ages of Bengali Boys. By Ainul Quari .. 323
16. Forgetting and Amnesia. By J. K. Sarkar 323
17. Some factors in the psychology and advertisement. By S. C. Sinha 324
18. Vocabulary study of two children, 3 years and 4 years old. By Gopeswar Pal 324
19. Perception of forms in indirect vision. By S. C. Mitra .. 324

		Page
20.	Monocular perception of distance. By S. K Bose ..	324
21.	A suggestion of a new method for the demonstration of Weber's law in the field of visual brightness. By Haripada Maity	325
22.	The influence of musical notes upon tremors. By M. N. Samanta.	325
23.	A study in the increase of subjective brightness in a circumscribed field. By M. N. Banerji	325
24.	On "Gestalt-Theorie." By N. N. Sen Gupta ..	325
25.	Intelligence tests for college freshmen. By G. C. Chatterji	325
26.	The comparative value of some single tests as measures of general intelligence. By Mohammad Aslam ..	326
27.	Retention by visual and by kinaesthetic presentation. By Mohammad Aslam	326
28.	McDougall's theory of laughter at the ludicrous. By R R Kumar	326
29.	Mysticism and Psychology.—An exposition of a psychological approach to the problem of the truth of Mysticism. By W. M Thomas	327
30.	International group mental tests. By S. C. Dodd ..	327
31.	Psychogalvanic and Psycho-circulatory reflexes of sense-stimulation	327
32.	Space limen in relation to the axis of rotation in the right arm. By K. C. Mookherji	328
33.	Statistical ethics. By G. H. Rao	328
34.	Experimental tests in the mental imagery of school children. By R. K. Chaube	328
	Index	329
	List of Members	357
	Rules, Indian Science Congress	373
	Appendix : Officers of the First Thirteen Meetings of the Indian Science Congress	375
	Statement of accounts of the 13th Indian Science Congress	383

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9.	Prof. R. V. Norris, D Sc., M.Sc., F.I.C.	

MEMBERS OF COUNCIL.

1–9. (a) *Members of the Executive Committee. Ex-Officio.*

(b) *Past Presidents resident in India.*

10. Sir P. C. Ray, Kt., C.I.E., Ph.D., D.Sc., F.A.S.B.
11. Sir R. N. Mukherji, K.C.I.E., K.C.V.O.
12. Sir M. Visweshwarayya, K.C I.E., M.Inst. C.E., D.Sc.
13. Dr. M. O. Forster, F.R.S.

(c) *Elected by the General Committee.*

14. Prof. S. L. Ajrekar, M.A.
15. Prof. D. M. Bose, M.A., B.Sc., Ph.D.
16. Prof. H. C. Das-Gupta, M.A., F.G.S.
17. Prof. G. Mathai, M.A., F.Z.S.
18. Dr. E. R. Watson, M.A., D.Sc.

The fourteenth meeting of the Indian Science Congress was held in Lahore from January 3rd to the 8th, 1927. After a speech of welcome from H. E. Sir Malcolm Hailey, Governor of the Punjab, the President Sir J. C. Bose, Kt., F.R.S., delivered his address.

The Sectional Presidential Addresses were delivered as follows :—

Tuesday, January 4th, 10 A.M. Mathematics and Physics; 11 A.M. Botany; 12 noon; Anthropology.

Wednesday, January 5th, 10 A.M. Chemistry; 11 A.M. Zoology; 12 noon; Psychology.

Thursday, January 6th, 10 A.M. Medical and Veterinary Research; 11 A.M. Geology; 12 noon; Agriculture.

The following functions were arranged in connection with the Congress :—

January 3rd, Garden Party and Reception by Mian Sir Mahomad Shafi, K.B.E., K.C.S.I., C.I.E., at the Iqbal Manzil, 4 Mozang Road.

January 4th, Excursions to: (1) N.W. Railway Work Shop; (2) Shalimar Gardens; (3) Fort and Shahdara; (4) Automatic Telephone Exchange; (5) Tanning and Dyeing Factories, the Shahdara.

January 5th, "Science Dinner."

January 6th, Science Conversazione and "At Home" by Lala Harkissenlal.

January 7th, Excursions to: (1) The Raenala Hydro-electric works and the Archæological finds, Harappa; (2) The Jallo Rosin Factory and Amritsar.

Public lectures were delivered as follows :—

January 4th, "Snake Charmers and their Art" by Major H. W. Acton, M.R.C.S., L.R.C.P., I.M.S.

January 5th, "On the nature of things with special reference to the nature of radiations" by Professor A. H. Compton of the Chicago University.

January 6th, "Action of Alkaloids and Cobra-venom on Pulse-beat of animals and plants" by Sir J. C. Bose, Kt., F.R.S.

January 8th, "Animal life in torrential streams" by Dr. S. L. Hora, D.Sc.

The Executive Committee met on the January 6th.

The General Committee met on January 8th.

A souvenir volume "Glimpses of the Punjab" was issued to Members.

Presidential Address.

Congress President:—Sir J. C. Bose, Kt., C.S.I., C.I.E., D.Sc., F.R.S.

The Unity of Life

In presiding over the Indian Science Congress it is expected that I should give a connected account of my investigations that have been in progress for nearly a third of a century. The results obtained have led to the establishment of the important generalisation of Unity of Life; from this it followed as a corollary, that there must also be an unity of all human efforts and that in the realm of the mind there can be no boundaries and no separations. It is a misreading of the Laws of Nature to regard conflict as the only factor in evolution; far more potent than competition is mutual aid and co-operation in the scheme of life.

Nothing can be more untrue than the ignorant assertion that the world owes its progress of knowledge to any particular race. The whole world is interdependent, and a constant stream of thought has throughout ages enriched the common heritage of mankind. It is the realisation of this mutual dependence that has kept the mighty human fabric bound together and ensured the continuity and permanence of civilisation. Hellenistic Greeks and Eastern Aryans had met here in Taxila to exchange the best each had to offer. After many centuries the East and the West had met once more and it would be the test of the real greatness of the two civilisations that both should be finer and better for the stimulus of contact.

When I commenced my investigations about forty years ago, it was held that by its very peculiar constitution, the Indian mind would always turn away from the study of nature to metaphysical speculations. India was regarded as a land of magic and mysticism where no advance of positive knowledge could be expected. The hypnotic suggestion of inaptitude could only be removed after years of effort, and it is only recently that the generous declaration was made at the Meeting of Intellectual Co-operation, League of Nations "that India had hitherto been to the West, a land of dreams; they now recognised that these dreams had led to great discoveries. The intellectual co-operation now inaugurated would open out for the world the enormous reserves of thought of Asia, the cradle of civilisation."

It is now my good fortune to see that it is not one but all the provinces of India that are contributing to the advance of different branches of knowledge as is manifest from the activities of the different sections of this Science Congress.

India's Gift

Although science is neither of the East nor of the West, but international in its universality, yet India, by her habit of mind and inherited gifts handed down from generation to generation, is specially fitted to make great contributions in furtherance of knowledge. The burning imagination which can extort new order out of a mass of apparently contradictory facts, can also be held in check by the habit of concentration; it is this restraint which confers the power to hold the mind in pursuit of truth in infinite patience. The specific requirements for making great discoveries are vivid imagination, clear inner vision, great faculties of invention and experimental skill of the highest order. In order to discover the life mechanism in the interior of the tree one has to become the tree and feel the throbbings of its beating heart. This inner vision is, however, to be frequently tested by results of experimentation; for otherwise, it may lead to wildest speculation subversive of all intellectual sanity. A true inquirer has at every step to compare his own thought with objective reality; he has remorselessly to abandon all in which these are not agreed. Even in this path of self-restraint and verification, he is making for a region of surpassing wonder. When the note of the audible reaches the unheard, even then he gathers the tremulous message. Undaunted by limitations of our senses, he has to create artificial organs of unimaginable sensitiveness which requires great genius of invention and skill of construction. It is enough to say that Indian workers have shown a special aptitude in advancing science by their faculty of introspection, experimental skill and great power of invention.

The Economic Peril

The present unrest in India, as in Europe, is due to severe economic distress. On account of its magnitude, the danger is more acute here than any where else. In my travels I found poverty practically unknown in Norway and in Denmark. The miracle is accomplished through science, by utilising to the utmost all the available resources of the country. For the economic welfare of a vast continent like India, there must always be the two complementary activities, agriculture, and industry. On account of the uncertainty of rainfall, entire reliance cannot be placed on agriculture alone. There are, on the other hand, vast possibilities in exploitation of mineral

resources, and in the advance of industries. The Universities are turning out every year a large number of young men trained in methods of science who form the most important intellectual asset of the country, and who at present find no scope for their activities. It is the function of high statesmanship to foresee the economic danger and so shape the state policy that India's trained youth and her great potential wealth may be utilised for the benefit of the country. For this, the nation will willingly meet the necessary large expenditure, provided that the money is wisely spent for enriching India and in opening out wider spheres of activity for her children. There is also a large field of enterprise, where Indians and Englishmen could, as partners, find opportunities for co-operation and higher appreciation of each other.

The Mechanism of Life

Previous observers have been misled by the apparent differences between the reactions of animal and plant life. The animal responds to a shock by a twitching movement, while ordinary plants are supposed to be insensitive to a succession of blows. Animals possess sense organs which pick up messages from without, the tremor of excitation being conducted by means of the nervous tissue to the distant motile organ which it causes to move; the plant is supposed not to possess any such conducting tissue. A throbbing organ beats continuously in the animal, for circulation of the nutrient fluid; no similar organ has been suspected in the plant. Two streams of life are thus imagined to flow side by side with little in common between them. This view is wholly incorrect and it is the paralysing influence of wrong speculations that had arrested the advance of knowledge.

In opposition to current views, I was convinced that the mechanism of life of the plant is essentially similar to that of the animal. The demonstration of this would undoubtedly constitute a scientific generalisation of very great importance. For it would then follow that the complex mechanism of the animal machine that has so long baffled us, need not remain inscrutable for all time, since the intricate problems of animal life would naturally find their solution in the study of corresponding problems in the simpler vegetable life. This would mean the possibility of very great advance in the sciences of General Physiology, of Agriculture, of Medicine and even of Psychology.

The Realm of the Invisible

The real difficulty that thwarts the investigator at every step arises from the fact that the interplay of life-action is taking place within the dark profundities of the tree, which our eyes cannot penetrate. In order to reveal the intricate mechanism of its life, it is necessary to gain access to the smallest unit of

life, the 'life atom' and record its throbbing pulsation. When microscopic vision fails we have still to explore the realm of the invisible. Until this is done, the intricate problems of life will remain unsolved.

The experimental difficulties have been successfully removed by the invention and construction, in my Institute, of instruments of extreme delicacy and sensitiveness. These new devices by their automatic records, are now revealing the inner mechanism of life, and many regions of inquiry are now opened out which had hitherto been regarded as beyond the scope of experimental exploration. Out of a large number of inventions I will describe a few which render signal service in revealing the hidden activities of life. The *High Magnification Crescograph* instantly records the imperceptible growth, and the variation induced in it under chemical or electrical stimulation. The *Magnetic Crescograph* records movements beyond the highest powers of the microscope, the magnification produced being about 50 million times. Science is measurement, and this method of super-magnification has opened out possibilities for great advance in various branches of science. The *Resonant Recorder*, inscribes time as short as a thousandth part of a second, and enables the most accurate determination of the *latent* or perception period of the plant, and the velocity of transmission of excitation. The *Conductivity Balance* enables the determination of the effect of various drugs in enhancement or depression of the nervous impulse. The *Electric Probe* localises the conducting tissue for the transmission of impulse as also certain pulsating layer of cells in the interior of the tree. The *Electric Phytograph* is the only device for record of the rate of the ascent of sap and the variation induced in it. The *Transpirograph* has enabled determination of the quantity of water transpired by a single stoma of the leaf. The *Optical Sphygmograph* records the pulse-beat of the plant and its modification under various drugs. The *Photosynthetic Recorder* automatically inscribes on a moving drum the rate of carbon-assimilation by plants. It is so extremely sensitive that it detects the formation of carbohydrate as minute as a millionth of a gram. The *Magnetic Radiometer* enables accurate measurement of energy of every ray in the solar spectrum. In conjunction with a special Calorimeter, it has enabled the most accurate determination of the efficiency of the chlorophyll-apparatus of green plants in storage of solar energy.

Form and Function

Every organ of a living being is an instrument, subserving a particular function for the advantage of the organism. In physiology or the study of the phenomena of life, we are primarily concerned with investigations on the function of

the organ and not of its form. This will be clearly understood from the comparative study of different types of digestive organs, the primary function of which is to dissolve insoluble organic food by secretion from glands, and the subsequent absorption of the dissolved product. In *Drosera rotundifolia* the leaves are covered with tentacles which discharge a viscid acid secretion. Insects are caught by the secretion and during their struggle the neighbouring tentacles bend over and hold the victims more securely. The insects then become dissolved and digested, the insoluble skeleton being left behind. Nothing could be so strikingly different as this simple type of an open digestive organ from that of the more complex infolded stomach of the animal. Yet functionally one is as much a digestive organ as the other. In the case of Venus Fly-trap or *Dionaea*, a trap is formed by the two halves of the open leaf, which acts like a gaping mouth closing upon its prey—the captured insect. In the bag-like pitcher of Nepenthe, the digestive organ of the plant approximates more closely to the stomach of an animal.

The plant world affords an unique opportunity for studying the changes by which a simple and primitive organ becomes gradually transformed into one of greater complexity.

The evolutionary process has been active not only in morphological differentiation, that is, in the development of new forms, but also in physiological differentiation, that is, in the development of specialised mechanisms for performance of the various vital functions. There still exists a long prevalent idea that physiological mechanisms of animals and plants are fundamentally different, because they have been developed along separate lines. The evidence I will adduce will suffice to show that this idea is totally unfounded.

Animal and Plant Mechanism

The most important characteristics of certain animal tissues are (1) *contractility* on account of which response by movement takes place under external stimulus; (2) *conductivity* or power of transmitting excitation to a distance; and (3) *rhythmicity* or so called spontaneous movements. We have to investigate whether these characteristics are also to be discovered in the plant.

The above problems are to be studied in greater detail as follows:

We have to find out whether sensitiveness is characteristic only of a few plants, or whether all plants and their different organs are sensitive.

It is necessary to inquire whether muscular organs are present in the plant, whether such organs are simple or whether some of them had attained a high degree of complexity.

Various grades of activity are found in different muscular organs, and an attempt will be made to discover the cause of this difference.

Animal tissues are excited by various irritants ; are the plant tissues excited by similar agents ? Are the effects of various drugs identical in the two cases ? Does the effect of poison change with the dose ? Is it possible to counteract the action of one poison by means of another which acts as an antidote ?

All life movements cease at death ; what are the symptoms of death ? Is it possible to detect the exact critical moment ?

Certain animal tissues like the heart, exhibit rhythmic movements which appear to be initiated without any cause. No explanation had been offered for these mysterious spontaneous or automatic movements. Are there any rhythmic tissues in the plant which beat spontaneously ? If so are the characteristics of rhythmic tissues in plant and animal similar ? Do investigations on plants lead to the solution of the mystery of spontaneous activity or automatism ?

Growth furnishes with one of the most important examples of automatism. Yet the rate of growth in a plant is far below anything we can directly perceive. How then is growth to be so magnified as to be rendered instantly measurable ? What are the conditions which enhance or inhibit growth ?

In the animal, the throbbing heart maintains the circulation of blood. Alkaloids produce characteristic modifications of the pumping mechanism, in consequence of which appropriate changes of blood pressure are produced. How is the circulation of sap maintained in the plant ? Is the propulsive mechanism in the plant essentially similar to that in the animal, and is the sap-pressure, like the blood-pressure, modified by the specific action of different alkaloids ?

Is there any sense-organ in the plant which enables it to orientate itself in regard to the vertical direction ? Is the mechanism similar in plant and animal.

For carrying out the incessant activity of its life-movements, the plant has to store a large amount of energy. This process of storage of sunlight is of cosmic importance. The laws of photosynthesis remain to be discovered, and the efficiency of the chlorophyll apparatus in storage of solar energy requires careful redetermination.

Finally the question arises whether the nervous system is confined only to animals, as has been generally supposed or whether the plant also possesses a conducting tissue which functions as a nerve.

The Sensitiveness of Matter

How did life make its first appearance on earth ? No life, as we understand it now, could have existed when the

earth was a mass of molten matter. It has been suggested that the seed of life was imported to this earth by the cosmic dust from other worlds ; but this would merely transfer the difficulty backwards. Or perhaps matter itself is sensitive, and has within itself the promise and potency of life, so that at some critical period of the earth's history, the environmental conditions may have favoured the appearance of life in its present form out of non-life.

My investigations have indeed shown that all matter is sensitive, and that they respond to mechanical or electrical stimulation. Over-stimulation was found to cause fatigue from which there was a recovery after a period of rest. Prolonged rest, however, made the substance inert and irresponsive ; it had in fact become lazy through lack of stimulation. A strong shock now stirred it up again into readiness for response. Two opposite treatments are thus indicated for fatigue from overwork, and inertness from long passivity ! Other experiments showed moreover, that while stimulating drugs cause an enhancement of response, poisons "kill" it altogether. It would thus appear that sensitiveness is inherent in matter and that there has been a continuous evolution from simple inorganic matter to the highly complex animal life.

Irritability of all Plants

The world of plants has been arbitrarily divided into sensitive and ordinary, the former being confined to a small class which like *Mimosa pudica* exhibits mechanical movement on stimulation. There are other plants, which after stimulation, are physically restrained from exhibiting that movement which has hitherto been accepted as a test of sensibility of the tissue. Mechanical movement is, however, not the only manifestation of excitation. For stimulation is found to induce an electrical change in the irritable tissue, the electrical response serving as a very reliable test of the vital condition of a tissue. By the employment of this test, I succeeded in proving that every plant and every organ of the plant is sensitive. The electric response of the plant exhibits an enhancement under stimulating drugs, whereas under narcotics it undergoes a depression. There is a complete abolition of response after the plant is scalded to death.

Muscular Organ in Plants

Movement in response to stimulation is very strikingly manifested by the sensitive pulvinus of Mimosa. The functional similarity between the two contractile organs, pulvinus and muscle, is not confined to the manifestation of outward movement, but can be traced to the ultimate protoplasmic mechanism.

In regard to rapidity of movement of animal muscle, the

reaction of the swift animal must be rapid, while in the sluggish, the response is slow. The wing-muscle of a bird of prey like the falcon is very active; that of the goose is less active, while the corresponding muscle of the domestic fowl is almost inactive, its power of flight being practically lost. What is it that confers extreme rapidity of action? Curiously enough, in the leaves of plants also there are three types of motor pulvinus—active, semi-active, and inactive—corresponding to the three types in the animal.

In *Mimosa pudica* the rate of movement in response to stimulation is very rapid, the contractile fall being completed in a time as short as a second. In other sensitive plants like *Neptunia* the rate of movement is so slow that the time taken for the leaf to complete its fall is more than a minute. Finally, the pulvinus of the Runner Bean-plant (*Phaseolus*) shows a movement which is very feeble and extremely sluggish.

Turning our attention to the motile organ, it is the contraction of the cortical cells of the pulvinus of Mimosa that produces the rapid fall of the leaf. The pulvinus of the Bean-plant is, as already stated, inactive, though its cortical cells are to all appearances similar to those of Mimosa. Anatomical similarity has hitherto been unduly pressed in determining the true function of an organ; the facts given above will show the misleading character of such a criterion. It is not anatomical structure, but the protoplasmic content of a tissue that confers on an organ its physiological efficiency for discharge of a specific function. The motility of an organ is, as we shall presently find, dependent on the presence of a certain active substance in the protoplasm.

Demarcation of muscular tissue.—If we examine a longitudinal section of the pulvinus of Mimosa under the microscope, it is impossible to observe where the contractile cells begin, where they end, and how they are distributed. I succeeded, however, in distinguishing them by selective staining with safranin. This stain produced the most remarkable results; it appeared as if a hand had, with utmost care, picked out every actively contractile cell and painted its protoplasmic contents a deep crimson. The outline of the contractile tissue now became sharply defined; the stained protoplasmic contents of the active cells showed under high microscopic magnification, a marked granular appearance. In the semi-active Neptunia, the stained active cells were found to be not at all compact as in Mimosa, but scattered in their distribution. No staining occurred in the pulvinar cells of the inactive Bean-plant, the active substance being here altogether absent. It is very remarkable that the activity of the animal muscle is similarly dependent on the presence and relative distribution of the active substance. The pulvinus of Mimosa may thus be regarded as functionally equivalent to an active muscle.

All movements are ultimately dependent upon oxidation or combustion. In an engine, the speed of the moving machinery is dependent on the rate of consumption of the fuel, the higher the rate of combustion, the greater the rapidity of movement. In the living machine also, the rate of oxidation plays an important part in the production of rapid movement, and in the present case, the active substance is found to be highly oxidisable.

The pulvinus of Mimiosa had hitherto been regarded as a simple motor organ which responded by a simple up-or down-response. In reality its four quadrants act like so many distinct effectors ; the upper and lower quadrants execute the up-or down-movements, whereas the left and right quadrants execute left-handed and right-handed torsions. Thus the leaf by its complex muscular organ, can adjust itself so as to follow the movement of the sun, which enables it to absorb the largest amount of light.

Visible signals of Death

I have succeeded in discovering several exact methods by which the dying organism records its own curve of death. The plant is placed in a thermal bath the temperature of which is gradually raised. At the definite fatal temperature of 60°C, a violent spasm occurs, which corresponds to the death-throe of the animal. An intense electric discharge also takes place at this crisis.

I have recently succeeded in devising a new method, the result of which is somewhat startling. It shows that a plant immersed in a heating bath suddenly loses its buoyancy, and sinks at the fatal temperature.

Automatism

One of the most puzzling phenomena connected with life, is the so-called spontaneous or automatic movements, apparently maintained without any ascertainable cause. Every movement, ordinarily speaking, is due to an antecedent stimulus; but a spontaneously pulsating heart is said to beat of its own accord and therefore regarded as an automatic organ. What is the solution of the mystery of this automatism ?

Although such automatic movements are usually associated with animal life, yet similar activities are found in plants like the Telegraph-plant, *Desmodium gyrans*. I have been able to establish the essential similarity between the automatic pulsation of the Telegraph-plant and that of the animal heart, similar effects being induced under variation of temperature, and under different chemical agents, carbonic acid, ether, chloroform and others. Poisonous acids arrest the pulsation of the heart at diastolic expansion ; alkaline poison , on the other hand, arrest it

at systolic contraction. It is wonderful to discover identical reactions in Desmodium. Poisonous acids arrest the pulsation at diastole, while alkaline poisons produce an arrest at systole. Finally the arrest induced by either of these poisons can be counteracted by the antagonistic action of the other.

These experiments conclusively demonstrate the fundamental identity of the pulsatory mechanism in the animal and in the plant. But the question still remains; what is the cause of these automatic movements?

Discovery of Connecting Link

Two classes of phenomena, are thus observed (1) in which a single stimulus produces a single response, and (2) in which movement takes place apparently without any cause. Is there a hiatus between the two, or is there a connecting link, the discovery of which might lead to an explanation of these mysterious automatic movements? Such a connecting link I have discovered in *Biophytum sensitivum*, a weed which grows in the neighbourhood of Calcutta. Its sensitive leaflets show excitation by a twitching movement. In experimenting with this plant it was observed that while a single moderate stimulus gives rise to a single response, a stronger stimulus gives rise to a *series of multiple responses*, the persistence of which depends on the strength and duration of previous stimulation. A portion of the incident stimulus thus becomes stored and held latent for subsequent expression. The response thus echoes, as it were, or reverberates.

Semi-Automatism

Under natural conditions, the plant is exposed to the action of various stimuli, supplied by its environment. It is exposed to heat, to the action of light, to the mechanical stimulus of air currents, and to the action of various chemical agents present in it or absorbed by it. From the joint action of these external sources of stimulation, the energy stored up by the plant becomes sufficiently great to cause an excitatory overflow. It was our want of sufficiently penetrative analysis of the previous history of the plant that led to the assumption that these movements were self-caused. The internal stimuli for such automatic movements are, in reality, external stimuli which have become trapped. Biophytum under normal conditions, reacts like an ordinarily responding plant, since it gives a single response to a single moderate stimulation. But under strong stimulation it gives multiple responses, which are apparently automatic. The connecting link, Biophytum, demonstrates the continuity between ordinarily and automatically responding plants.

A pronouncedly automatic plant can, on the other hand, be brought down to the condition of an ordinary plant. It is the store of excess energy that enables Desmodium to exhibit

spontaneous movements. Depletion of its store of energy by keeping the plant in the dark, soon brought its pulsation to a standstill. A fresh accession of energy was now found to renew the pulsation; a feeble stimulus produced a single response; a stronger stimulus gave rise to a series of multiple responses. When subjected to the normal stimulation of the environment it regained its automatic activity.

Growth

The phenomenon of growth furnishes us with another example of automatic activity. Can any similarity be discovered between this and other modes of spontaneous activity? Do variations of external conditions modify all automatic activities in a similar manner?

The question of growth and its modifications under external changes is a matter of great practical importance, for the world's supply of food depends on the growth of plants. It is, therefore, of the highest importance to be able to discover all those conditions which are favourable to growth. In what way do external agencies modify it?

The extreme difficulty of the investigation arises from the extraordinary slowness of growth. Even the proverbial slow-moving snail moves two thousand times faster than the tip of a growing organ. The average rate of growth is about $\frac{1}{100000}$ inch per second, a length which is half that of a single wave of sodium light!

Even with the magnifying growth-recorders, hitherto employed, it takes a very long time to detect and measure the rate. For accurate investigations on the effect of a given agent on growth, it is necessary to keep all other variable conditions, such as light and warmth, strictly constant during the whole period of the experiment. We can keep these conditions absolutely constant for only a few minutes at a time. Experiments which require several hours for their completion are, therefore, subject to serious errors which vitiate the results.

The only satisfactory method is one that reduces the period of the experiment to a few minutes; that, however, necessitates the devising of an apparatus for very high magnifications, and for the automatic record of the magnified rate of growth. This has been accomplished by my High Magnification Crescograph which records growth magnified from ten thousand to fifty million times.

Like other modes of automatic activity, growth is found to be rhythmic or pulsatory. There is a sudden uplift followed by a slower recoil, the amount of recession being about one-fourth of what had been gained. The difference between the two represents permanent growth. The growth process is, therefore, not steady, but is like the wavelets of a rising tide.

Effect of Chemical Stimulants

Any marked advance in scientific agriculture is only possible if we succeed in discovering agents which greatly enhance the activity of growth. Only a few stimulating agents have been used for this purpose, whereas there are numerous others of whose action we have been profoundly ignorant. The rule-of-thumb method hitherto employed in the application of a few chemical stimulants and of electricity has, moreover, not been uniformly successful. The cause of this anomaly is found in the discovery of an important factor, namely, that of the amount of dose, which has hitherto not been taken into account. I thus find that while a particular intensity of electrical current accelerates growth, any excess above a critical point retards it. The same is true of chemical stimulants. A striking result was obtained with certain poisons, which in normal doses kill the plant, but in excessively minute doses acted as an extraordinarily efficient stimulant in promoting growth. Plants, in fact, behave in this respect like human beings. Investigations on plants thus open out fresh lines of research for Pharmacology and Medicine.

Not only is growth modified by the intensity of the stimulus, physical or chemical, but also by the point of its application and by the tonic condition of the plant. In regard to the point of application direct stimulation induces a retardation of growth, while indirect stimulation enhances the rate.

Modifying Effect of Tonic Condition

In medical practice, anomalies are frequently met with, in which the same drug induces diametrically opposite effects of different individuals. The cause of the anomaly lies in the fact that the tonic level or constitution of different individuals is not the same. For rational treatment, it is essential to take into account the constitution of the patient, for the reaction of a given drug is greatly modified by this tonic condition.

In experimenting with plants, I artificially modified the tone or constitution of different batches of similar seedlings. One was kept normal for reference, another depressed to a subtonic condition, and the third raised to an optimum state of exceptional vigour. A measured dose of dilute poison was applied to the three batches of plants. The normal plants survived after a period of struggle. The weaker specimens succumbed at once and without any struggle. But the reaction of the vigorous specimens was quite different; the toxic agent not only failed in its illegitimate work, but actually exalted the growth of its intended victims!

Wireless Waves on Growth

I investigated the range of perception of the plant in regard to the visible and invisible rays. The plant responds to

ultra-violet light with its extremely short wave-length. The effect of light on growth declines towards the yellow and the red. As we proceed further into the infra-red region, we come across the vast range of electric radiation the wave-lengths of which vary from the shortest wave that I have been able to produce (0·6 cm.) to others which may be miles in length. The results of my investigation show that wireless waves produce characteristic variations in growth, depending on the intensity of stimulus Feeble waves produce an acceleration, while stronger waves produce a retardation of the rate of growth. The perceptive range of the plant is inconceivably greater than ours; it not only perceives, but also responds to the different rays of the vast ætherial spectrum.

It is perhaps as well that our senses are limited in their range. For life would otherwise have been intolerable under the constant irritation of these ceaseless waves of space-signalling to which brick walls are quite transparent. Hermetically sealed metal chambers would then have afforded us the only protection!

The Sense of Direction in Plants

The force of gravity stimulates a plant-member when that member has been removed from the vertical. The problem before us is, first, the determination of the means by which geotropic irritation is effected and second, the exact localisation of the sense organ by which the plant is able to perceive when it is out of the vertical, thereby directing its movement so as to become once more erect. How does the plant perceive the vertical direction in space? Masons get their idea of the exact direction of the force of gravity by the use of the plumb-line, that is to say by a hanging weight. And we ourselves obtain the direction of space by means of the semi-circular canals in our internal ear. The contained fluid exerts varying pressure in different positions, and thus gives us an idea of the vertical direction. In the lower animals, the lobster for example, there are 'otoliths' and sandgrains mingled with tactile hairs, which by their vertical pressure give these animals their sense of direction in space.

There is good evidence that solid particles such as starch grains contained in the cells of certain tissues of plants, serve as otoliths, giving the signal and stimulus for vertical adjustment. Observation of the distribution of the starch grains in the cells and the consideration of the changes in their position led to the theory of statoliths ably advocated by Nêmec, Haberlandt and others.

Various objections have been raised to this theory since the evidence in its support is of an indirect nature. The direct test must lie in ascertaining if the change in position of starch

grains is accompanied by a physiological reaction giving an unmistakable signal of perception of geotropic stimulation by the plant, as it is displaced from its normal vertical position.

The Electric Probe

It is necessary, in fact to make an exploration inside the still living plant to discover if the particular layer containing the statoliths is the one most irritated by geotropic stimulation. This exploration was carried out by my Electric Probe; when the Probe suitably connected with a galvanometer, is slowly thrust into the stem, the galvanometer, by its deflection, shows the state of irritation, if any, of every layer of cells through which it passes. When the stem is vertical there is no sign of any local irritation. The case is very different when the stem is displaced from the vertical to a horizontal position. The geotropically sensitive layer now perceives the stimulus and becomes the focus of excitation as evidenced by the maximum negative electric response registered by the galvanometer. The intensity of responsive electric change is observed to decline in both directions outwards and inwards from the focus. After localising the perceptive layer by the electric explorer, I made a section of the organ, and found that the cells of this layer contained large-sized starch grains which by their weight were instrumental in causing stimulation. The excitation caused by falling starch grains was thus directly observed.

Propulsion of blood and of Sap

The question of propulsion of sap in the plant has for a long time been regarded as an insoluble problem. Is it a physical or a physiological phenomenon? Strasburger wrongly imagined that the movement of sap was unaffected by the action of poison: hence various physical theories have been proposed which failed to offer any satisfactory explanation of the phenomenon. My experiments on the action of stimulants which revive the ascent in a dying plant, and of poisons, which abolish it in a vigorous plant prove, on the other hand, that the movement of sap is brought about by a throbbing propulsive tissue which functions both as the pumping heart and artery.

In lower animals such as Amphioxus the propulsive mechanism is an elongated organ in which a series of peristaltic waves propel the nutrient fluid. Even in higher animals, the embryo has an elongated tubular heart. I have been able to demonstrate that the propulsion of sap is not wholly a physical but fundamentally a physiological process, not essentially different from the mechanism of propulsion of blood in the animal.

Cardiogram and Sphygmogram

The normal activity of the animal heart and the change induced under drugs can be found directly by the cardiograph which is essentially a magnifying lever.

The change of cardiac activity can also be indirectly obtained by the pressure-variation on the artery, recorded by the Sphygmograph. When the activity of heart-pump is increased, the blood pressure is increased, a depressant producing the opposite result. The radial artery on the wrist is on the surface and it is not difficult to record its pulsation. But no record is possible when the artery is buried under other tissues.

The Optical Sphygmograph

Turning next to the plant, any attempt to feel its pulse would, by the very nature of the case, appear to be hopeless. If the plant propelled the sap by periodic pulsation of the active layer, the amount of expansion and contraction of each pulse would be beyond even the highest powers of the microscope to detect. The active cells are, moreover, buried in the interior of the plant; how could the invisible and the hidden be rendered visible ?

I nevertheless succeeded in my attempt to record the pulse-throb during the passage of the sap-stream as it is pumped up along the stem. The passage of each pulse is attended by an infinitesimal expansion. After the brief passage of the pulse-wave, the stem would revert to its original diameter. In case of identical mechanism in plant and animal, a cardiac stimulant would make the heart-pump of the plant act more energetically, driving the sap faster, causing a greater inflation of the stem. Under depressants the change would be of an opposite character. For recording these infinitesimal dilatations or contractions, it was necessary to construct artificial organs of perception of surpassing delicacy and sensitiveness. The Plant-Feeler or the Optical Sphygmograph, which I have devised, consists of two rods, one of which is fixed and the other movable, the stem of the plant being placed between the two. The movement of the end of the free rod is further magnified by an optical device, the total magnification being about 5 million times. When a dead plant is placed in the apparatus, the indicating line of light remains quiescent, its pulse-beat having been stilled in death. But the imperceptible pulse-beat in the living plant is outwardly manifested by the alternate swings of the beam of light. A depressing agent causes diminished pressure shown by the rush of light to the left, whereas increased pressure caused by a stimulant produces a rush of light-beam to the right. The waxings and wanings of life are thus for the first time revealed by the moving trail of light.

Action of Alkaloids on Pulse-beat

Drugs and alkaloids produce modifications of pulse-beat of animal and of plant which are extraordinarily similar. Those which stimulate the cardiac activity also stimulate the propulsive activity in the plant; depressants, on the other hand, induce opposite effects in both.

Effect of Cobra-Venom

Cobra-venom acts on the animal as a deadly poison even in minute quantities. I found the effect on the plant was identical. I was greatly interested to find that a preparation of cobra-venom known as *Shuchikavaran*, the principal constituent of which is a minute quantity of cobra-poison, has been employed as a cardiac stimulant in the Hindu System of Medicine for nearly a thousand years. I found that minute doses of cobra-venom caused a great stimulation of the pulsating activity of the plant. Similarly, injection of *Shuchikavaran* in the blood stream of the animal in a state of depression, was found to produce a marked improvement in the frequency and amplitude of pulsation of its heart-beat.

Carbon-assimilation

The incessant activities of life require expenditure of energy previously stored by the organism. Taking for example the rise of sap, the ceaseless activity of the pulsating tissue raises enormous quantities of water to a considerable height. The energy of doing this work resides in the break-down of organic chemical substances in internal combustion or respiration. The loss of energy must be restored by absorption and storage of energy from outside.

The Photosynthetic Recorder

The activity of assimilation may be measured either from the volume of carbon-dioxide absorbed or an equal volume of oxygen evolved. The first method is very complicated while the second is simple and direct. My Photosynthetic Recorder automatically records the rate of assimilation on a revolving drum; it also gives audible signals. The automatic method is extremely sensitive and eliminates personal errors of observation.

Effect of Infinitesimal Traces of Chemical Substances.

One of the most astonishing results, was the discovery of the extraordinary increase in the power of assimilation by inconceivably small traces of certain chemical substances.

It is found that when these are diluted, one part in a billion, they produce an increase in the power of assimilation of more than a hundred per cent. Formaldehyde, which in large doses acts as a poison, is found in a solution of one part in a billion, to produce an increase of activity of eighty per cent. The stimulating effect of traces of formaldehyde has a special significance in regard to the "first product" of photosynthesis, which is believed to be formaldehyde. The poisonous nature of this substance stood in the way of acceptance of this view, but the experiment just described shows that traces of this substance, instead of being poisonous, have the effect of increasing the photosynthetic activity.

Law of Photosynthesis

In nature the photosynthetic organ is acted upon by numerous changing factors. It is the high complexity introduced by the numerous combinations of the constituent factors which renders the analysis of life-processes so extremely difficult. The problem has been greatly simplified by the establishment of the Law of Products, and introduction of measurement in the physiological scale. A simple formula then suffices to determine the combined effect of any number of factors in the final result.

Storage of Solar Energy

The economic life of the present age may be said to depend to a great extent on the utilisation of the solar energy that has been stored in past ages by vegetable life. What is the efficiency of the plant-mechanism for this storage? It has hitherto been regarded as extremely low, less than 1 per cent. The methods employed in this determination have hitherto been more or less defective. I, therefore, undertook a careful re-determination by the employment of new and highly sensitive methods. The efficiency was found to be much higher than had generally been supposed, being as high as 7·4 per cent. The efficiency of the photosynthetic organ may be taken as about half that of an ordinary steam-engine. After all, it may not be such an impractical proposition to devise a chlorophyll apparatus for trapping sunlight.

The Nervous Impulse in Plants

The possession of a nervous system has been denied in the case of plants; my investigations prove, on the other hand, that not only has a nervous system been developed, but that it had attained a high degree of complexity as marked by the reflex arc in which the sensory becomes transformed into a motor impulse. The absence of methods of quantitative

measurements has, in the past, led to various unfounded speculations. One of the most grotesque theories recently advanced is that the transmission of excitation in *Mimosa pudica* is due to the excretion of a stimulant by a knife-wound, the stimulant being then carried by the movement of sap caused by the transpiration current. This is a misapplication of the theory of hormone as enunciated by Starling and Bayliss. There are two different modes of communication between distant organs, by *transfer of matter*, and by *transmission of motion*. The first is exemplified by the slow movement of liquids carrying chemical stimulants in solution, such as occurs in the ascent of sap in the plant ; the second is the *rapid* conduction of molecular tremor, from point to point, associated with the propagation of nervous impulse. These two different modes have been aptly likened to communications by post or by telegraph. The difference between the two speeds is so great that it would be an unpardonable mistake to confuse one with the other. The nervous impulse in the plant is sometimes as high as 400 mm. per second and is, therefore, several hundred times quicker than the slow rate of ascent of sap. The transpiration current theory presupposes that a wound-stimulus is essential for secretion of a stimulant and that the impulse should always move upwards in the direction of the ascent of sap. I have shown, however, that stimulation can be produced in complete absence of wound and by an electric-shock one-tenth the intensity that evokes human sensation. No demonstration of the totally unfounded character of the transpiration current theory could be more simple and convincing than the observation of the effect of the application of a drop of hydrochloric acid to the tip of the uppermost leaf of Mimosa. The ascent of sap was here impossible ; yet an impulse was generated which travelled to a considerable distance downwards, against the direction of the normal ascent of sap. Subsequent chemical examination proved that the stimulant had not been transported, but had remained localised at the point of application.

Water-pipe or Nerve

It is obvious that the mechanical movement of water through a pipe will in no way be affected by heat or cold ; the pipe will not lose consciousness and stop the flow of water if it be chloroformed, nor will its power of conduction be abolished by applying round it a bandage soaked in poison. These physiological blocks produce, however, a temporary or permanent arrest of the impulse which must therefore be of a nervous character. My further discovery of the excitatory polar action of an electric current and its transmission to a distance, proves conclusively that the conduction of excitation in the plant is fundamentally the same as that in the nerve of the animal.

The Anchored Moth

The leaf, like an anchored moth, turns towards the light, by up or down movement, or by twists to the left or to the right. The movements take place when the leaflets carried by the four sub-petioles alone are exposed to the light, the distant motor organ, the pulvinus, being shielded from it. The attitude of the leaf perpendicular to the light is therefore due to the co-ordinated reflexes produced at the distant pulvinus by nervous impulses sent by the leaflets which perceive the light.

Discovery of Reflex-Arc

When a stronger stimulus is applied, a different class of phenomenon makes its appearance; the afferent or sensory impulse reaching the central end at the pulvinus becomes reflected along a new path as an efferent or motor impulse which travels outwards. The outlying organs are thus quickly adjusted to meet any crisis; there is always a ceaseless alertness and immediate executive action to meet emergencies. For any disharmony means the destruction of the plant common-wealth.

Invisibility as a Means of Protection

These discoveries prove that not only has a nervous system been evolved in the plant, but that it has reached a very high degree of complexity as marked by the reflex arc. The question arises as to what advantage is secured by such a highly elaborated nervous system. One advantage, as already explained, is the co-ordinated reflex by which the leaf surface is adjusted perpendicularly to the incident light, so as to ensure the absorption of the largest amount of radiant energy for photosynthesis. Another important function is the transmission of a rapid message to the motor organ for quick reaction in avoiding threatened danger. Large patches of ground in the tropics are covered by Mimosa with their vivid green leaves; when one of the leaves is trampled upon or bitten by grazing cattle, a nervous impulse is sent throughout the plant; the leaves fall and press themselves against the ground and the leaflets also become closed. Nothing could be more striking than the rapid change by which a patch of vivid green becomes transformed into thin lines of dull grey unnoticed against the dark ground. The plant thus saves itself by literally "lying low" and becoming invisible.

The Control of Nervous Impulse and Sensation

It is one of the greatest of all mysteries how we are brought nto contact with the external world; how blows from without

are felt within. Our sense-organs are like so many antennae, radiating in various directions and picking up messages of many kinds; these bear, moreover, a certain potentiality to induce in us a sensation which may either be agreeable or disagreeable. The quality of the sensation is often affected by the intensity of the impinging stimulus. It is well known that while a gentle touch or moderate stimulus of light, heat, or sound may produce a sensation which may be described as pleasant, an intense stimulus of the same nature causes a sensation which is extremely unpleasant or even painful.

The intensity of the impulse that reaches the central organ depends on two factors, the strength of the external stimulus and the condition of the vehicle that conducts the impulse. Under normal conditions, extremely weak stimulation gives rise to an impulse which is so feeble that it can not be transmitted and therefore remains below the threshold of perception. Moderate stimulation gives rise to responsive sensation not unpleasant; very strong stimulation, on the other hand, causes an intense reaction of a painful character.

Our sensation is thus coloured by the intensity of the nervous excitation that reaches the perceptive organ. We are subject to human limitations, through the imperfection of our senses on the one hand, and our over-sensibility on the other. There are happenings which elude us because the stimulus is too feeble to waken our senses; the external shock may, on the other hand, be so intense as to fill our life with pain. Since we have little power to alter the external world, is it possible to control the nervous impulse itself so that it shall be exalted in one case and inhibited or obliterated in the other? Does science hold out the hope of any such possibility? This question is plainly fraught with high significance.

Problem of Nervous Control

There is much resemblance between the conduction of electric impulse by a metallic wire and of excitatory impulse by a nerve. In the metal the power of conduction is constant, and the intensity of the electric impulse simply depends on the intensity of the electric force that is applied. If the conducting power of the nerve were constant, then the intensity of the nervous impulse and the resulting sensation would entirely depend on the intensity of the impinging stimulus. In that case, modification of sensation would be an impossibility. But there may be a likelihood that the power of conduction possessed by a nerve is not constant, but capable of change, so that the resistance to the passage of the impulse can either be decreased or increased. Should this surmise prove correct, then we arrive at the momentous conclusion that sensation itself is modifiable, whatever be the external stimulus.

Effect of Molecular Predisposition

The thrill produced by stimulation of the receptive outer end of the nerve, is sent inward from point to point of the conducting thread, as a molecular disturbance. An acceleration or inhibition of impulse will evidently be produced by two opposite molecular dispositions. The molecules may be visualised as a row of standing books. A certain intensity of blow applied, say to the book on the extreme right, causes it to fall to the left, hitting its neighbour and making the other books topple over in succession. If the books had previously been tilted slightly to the left, a disposition would have been given to them which would bring about an upset under a feebler blow and accelerate the speed of the impulse. A tilt in the opposite direction would, on the other hand, be a predisposition to retard or inhibit the impulse.

Is it at all possible to induce opposite molecular dispositions in the nerve, so that in the one case a sub-liminal stimulus will be effectively transmitted and brought into sensory prominence; and an intense wave due to a violent stimulus may, on the other hand, be inhibited during transit and thus become obliterated ?

For this the molecules of the nerve have to be coerced at one's bidding into arranging themselves favourably or unfavourably for the passage of impulse. I succeeded in effecting this by the employment of an electric force of a polar character. The results obtained are of extraordinary interest; by conferring on the nerve a favourable molecular disposition, a feeble stimulus previously below the threshold of perception now produced an extraordinarily large response. Conversely, an intense excitation generated by a violent stimulus was arrested during transit, by the induction of an opposite molecular disposition of the nervous tissue. Thus under a particular molecular disposition of the nerve, the experimental frog responded to a stimulus which had hitherto been below its threshold of perception. Under the opposite disposition, the violent spasm under intense irritation caused by application of salt was at once quelled as if by magic.

Power of Directive Control by Will

The foregoing experiments have demonstrated that two opposite molecular dispositions can be induced in nerve by the polar action of a constant electric current accelerating or inhibiting the passage of the impulse. The question naturally arises whether or not the action of the Will upon the nerves of the body may not be of a similar nature.

Now, full scientific attention has not been given to the power of our Will in controlling all bodily functions. Very few have realised how great becomes the power of Will intensified

by practice and concentration. There can be no doubt of the predispositions which can be conferred on the nerve by internal power of Will in facilitating or inhibiting the nervous impulse. The effect of attention or expectation in enhancing perception is familiar as also is the power of suggestion.

Man victorious over Circumstances

In the determination of sensation, then, the internal stimulus of the Will may play as important a part as the shock from outside. And thus, through the inner control of the nerve, the character of the resulting sensation may become profoundly modified. The external, then, is not so overwhelmingly dominant, and man is no longer a passive agent in the hand of destiny. He has a latent power which will raise him above the terrors of his inimical surroundings. It rests with him whether the channels through which the outside. world reaches him should at his command be widened or closed. It should thus be possible for him to catch those indistinct messages that have hitherto passed by him unperceived; or he may withdraw within himself, so that in his inner realms the jarring notes and the din of the world no longer affect him.

From the plant to the animal then, we follow the long stairway of the ascent of life and see the higher and higher expression of that evolutionary process by which life rises above and beyond all the circumstances of the environment, and fortifies itself to control them.

The following works published by Messrs. Longmans and Green may be consulted for detailed information :—

Bose—Response in the Living and Non-Living	..	1902
,, Comparative Electro-Physiology ..	..	1907
,, Irritability of Plants	..	1913
,, Life Movements in Plants 3 vols.	..	1918–23
,, Physiology of the Ascent of Sap ..	..	1923
,, Physiology of Photo-synthesis	..	1924
,, Nervous Mechanism of Plants ..	..	1926
,, Plant-Autographs and their Revelations	..	1927

Section of Agriculture.

President :—F. J. Warth, Esq., M.Sc.

Presidential Address.

The Capacities of Indian Cattle for Food Consumption and Digestion.

There is a tendency to look upon the study of animal nutrition simply as a study of food stuffs and their utilisation by a standardised food consuming machine, the animal. Are we justified in assuming such uniformity amongst our cattle? We have in India a vast number of well characterised breeds of cattle which differ from one another to an extent and in ways which we have no notion of at present. Is it not possible that these breeds possess characteristics in their capacity for food consumption and digestion? The newly established Nutrition Section at Bangalore has not been able to study this question directly. Our primary work has been the study of food stuffs. Many of our fodders are peculiar to the country and very little outside information is available regarding their nutritive value. It is therefore right that the initial work should aim at obtaining this essential preliminary information. In the course of our work on food stuffs, however, we constantly find ourselves faced with peculiarities in our cattle. A few examples will show how these peculiarities have revealed themselves.

1. Bullock experiments with rice straw. From a long period feeding test which was concluded recently at Bangalore it was found that 100. lbs. of dry rice straw yield about 40 Starch equivalents. This is the practical working figure we wanted. But rice straw has also been tested in America and the result obtained there was only 25 Starch equivalents. Does this mean that our rice straw is so much superior in quality? Chemical analyses show that there is no material difference between the American and Indian products. We are therefore forced to conclude that the observed difference in nutritive value is due to a higher digestive capacity possessed by our bullocks. This explanation is borne out by digestion experiments. In America the bullocks digested 42 lbs. of organic matter from 100 lbs. of straw whilst our bullocks digested 49·9 lb. At the very outset of our work therefore we have found a marked difference between Indian and American cattle.

2. Preliminary experiments on milk production at Bangalore showed that our Cross-bred cows produced milk very economically. Digestion experiments showed that this economical

production was partly due to the efficient digestion of crude fibre by our Cross-bred cows.

Further experiments indicate that our pure-bred Indian cows may be even more efficient than Cross-breds in this respect.

3. Comparison of hay and rice straw. A short time ago an eminent authority on animal nutrition in England visited the Nutrition Section at Bangalore. He was struck by the relatively high Net Energy values which we had obtained for a number of typical samples of Indian hay. Whilst the figures obtained were reasonably good, the specimens of the fodders did not give such a good impression. We were able to explain this apparent anomaly by referring to the work on rice straw. The high digestion results with Indian hay had been obtained by using the same efficient bullocks which gave 40 starch equivalents for rice straw instead of 25. Our hay samples therefore are not nearly as good as they appear to be if we judge them by tests with our bullocks. From these examples we conclude that the digestive capacity of cattle may vary according to breed. We have to pass on now to the subject of food consumption.

Capacity for food Consumption.

The productive value of a ration is roughly measured by the amount of food digested, and the amount digested depends upon two factors, namely, the digestibility of the food and the amount of food consumed. Accordingly consumption is one of the two equally important factors in profitable cattle feeding. We have to ask therefore in the first place whether there is any marked constancy in the matter of food consumption by cattle. This question can be satisfactorily answered by referring to an experiment recently carried out at Bangalore.

A number of calves ranging in live weight from 150 lbs. to 250 lbs. was selected They were given concentrate strictly in proportion to their live weights. Roughage was given *ad lib.* and the amount consumed by each animal was determined daily for a period of three months. It was found that the roughage consumption and the consumption of total dry matter were both strictly in proportion to the live weight. The results were so regular that they could be plotted on a smooth liner graph. The experiment shows that healthy calves of uniform breed consume food in remarkably constant amounts, with different food stuffs, however, consumption may be profoundly altered, as the following experiment on roughage feeding shows.

Two groups of animals were used for the test. One group received hay, the other group received silage of the same material cut at the same time. These roughages were fed *ad lib.* and the daily consumption of each animal was determined

as usual. Concentrate was fed in equal amounts to both groups. Table I shows the results of this test.

Per head per day.	Silage group.	Hay group.
Concentrate consumption in lbs. dry matter	2·700 ..	2·700
Roughage consumption in lbs. dry matter	8·363 ..	5·860
Total food consumption in lbs. dry matter	11·063 ..	8·560

The striking point in these figures is the difference in consumption of the two roughages. From these experiments on food consumption we learn that animals of the same breed and size eat very uniformly of the same ration, but that alterations in the rations are liable to have a profound effect upon the amount of food consumed.

Consumption in relation to breed.

In the course of our work on food stuffs at Bangalore we have obtained a few figures bearing on this subject. The best case was met with in an experiment designed to test the ordinary Dairy ration for young heifers. A collection of various Cross-bred heifers was made irrespective of pedigree and a test was carried out for 100 days. There was no intention of comparing breeds. We simply took a number of typical animals. Concentrate and a little silage were fed in fixed amounts. Hay was fed *ad lib.* and the quantity consumed was determined daily.

Table II shows the average daily food consumption of these animals. Consumption in lbs. dry matter per day.

	Animal No.	*Concentrate.*	*Silage.*	*Hay.*	*Total.*	
Younger group.	1 ..	2·722	1·158	4·078	7·958	
	2 ..	2·780	1·158	5·147	9·085	(H)
	3 ..	2·724	1·136	3·963	7·823	
	4 ..	2·671	1·158	3·866	7·695	
	5 ..	2·778	1·148	4·980	8·906	(H)
	6 ..	2·670	1·158	3·675	7·503	
Older group.	1 ..	3·614	2·368	6·478	12·460	(H)
	2 ..	3·616	2·366	6·498	12·480	(H)
	3 ..	3·608	2·256	5·476	11·340	
	4 ..	3·559	2·249	5·342	11·150	
	5 ..	3·608	2·252	5·120	10·980	

It will be noticed that two animals in each group consumed more roughage than their mates.

The interesting fact is that these four animals had Holstein blood in them and the others had not. This is a clear case in which food consumption was influenced by breed.

A second case refers to data obtained with cows. We have two sets of results from Cross-bred cows obtained respectively at the height of lactation and again when the milk yield had fallen. For comparison we have one set of figures from Scindi cows. In all these experiments concentrate was fed in definite amounts and roughage was fed *ad lib.* the quantity consumed being determined daily.

Table III gives a summary of the average results.

Average daily consumption in lbs. per 1000 lbs. live weight.

Class.	Roughage.	Concentrate.	Dry matter.	Percentage. digestion.	Ratio R/C.
Cross-bred (1st test) ..	19·20	13·02	32·22	53·59	1·47
Cross-bred (2nd test) ..	18·51	9·86	28·31	54·60	1·86
Scindi	16·30	13·22	29·53	58·27	1·23

The points to note are :—

(*a*) The Cross-breds consumed more food when their concentrate was higher.

(*b*) The Scindis received as much concentrate as the Cross-breds in the first test but they consumed less roughage. It appears therefore that their consumption capacity is less than that of Cross-breds.

(*c*) The Scindis gave higher digestion results than the Cross-breds.

This higher digestion may however be due partly to the higher proportion of concentrate in the Scindis' ration. Further tests are required to compare these two classes of cows effectively. So far, we can say that the Cross-breds appear to have a decided advantage in their higher capacity for food consumption but they may lose a part of this advantage on account of less perfect digestion.

A third case in which consumption appears to depend on breed has been met with. In this instance animals of two pure indigenous breeds were used to make up a sufficient number for carrying out a food stuff test. There was no intention of comparing breeds. The feeding was done according to our usual practice, concentrate being given in equal amounts to all and roughage *ad lib.* to each. On comparing the data for the two breeds it was found that one lot generally consumed a little more than the other. While Breed A consumed 103·3 lbs., Breed B consumed 97·6 lbs. There was a difference of 5·7 lbs. with a probable error of 1·75. In this case the difference is so small that judged mathematically it is not a probability, it is only a possibility.

These observations which were made in the course of other work may be summed up in a few words. Both the nature of the food and the breed of the animal influence the amount consumed and the amount digested. The nature of the food exerts a greatly preponderating effect and hence the main work on animal nutrition must be concerned with food stuffs, but the fact that the breed may also exert a perceptible effect deserves attention for it is just this perceptible effect which may make a breed more suitable or less suitable under particular circumstances. Our views on the scope of nutrition work should be widened to embrace this aspect which has a distinct bearing on cattle breeding and selection.

Abstracts of Papers.

1. Influence of nutrition on human and animal welfare.

P. LANDER.

2. Some Dairy Problems.

W. SMITH.

3. The effect of manuring a crop on the vegetative and reproductive capacity of the Seed.

B. VISWA NATH *and* M. SURYANARAYANA, Coimbatore.

The paper describes crop experiments to test the influence of manuring on the quality of the resulting seed and gives a summary of certain nutritional experiments by Lieut.-Col. R. McCarrison, C.I.E., in-charge of the Deficiency Disease Inquiry.

The results of several plant experiments in pots, small plots and on field scale, with the seeds from the different Permanent Manurial Plots, Coimbatore, have shown that, apart from the aspect of yields, *manuring* has an important bearing on the nutritional and cropping value of the resulting seed.

The seed from a crop manured with cattle manure has been shown to possess a better nutritive value and when sown in a soil of moderate fertility, gave a larger yield of crop than the seed from a crop receiving either chemical manure or no manure. Similarly, the seed from a crop manured with mineral manure possessed a better nutritive value and on being sown, gave a larger crop than in the case of the seed from a no manure plot. The superiority of the seed from a crop receiving mineral manure over the unmanured one varied with the nature of the crop.

The weight and the chemical composition of the seed failed to offer an explanation for the remarkable efficacy of the "Cattle manure seed" in nutritional and cropping tests.

It is, therefore, supposed that seed from a crop manured with cattle manure contains *some vitalising* principle—referred to as vitamin or —auximone for the sake of brevity and expressiveness—in a comparatively larger measure than the "No manure seed" or "Mineral Manure seed."

The seed with a better nutritive and vitamin value also possessed better growing and cropping value. Yeast which is known to provide vitamins for animals was found to accelerate crop growth. That is, a better "auximonic" effect was accompanied by a better vitamin value and *vice versa* a better vitamin value was accompanied with a better—"auximonic" effects.

Based on this observation and other experimental evidence described in the paper, a hypothesis has been advanced that a certain active constituent or a group of constituents are involved in the co-operative cycle of plant and animal life.

With the aid of this hypothesis the role of organic matter and of the micro-biological population in the soil in their direct effects on plant nutrition are discussed and the observed differences in the cropping and nutritive values of seed from differently manured crops are explained.

The importance of organic manures to South Indian soils is em-

phasised and suggestions are made for the future manurial policy to be followed.

4. Breeding improved Sugarcanes for the Punjab.

T. S. Venkatraman, Coimbatore.

A brief outline is given of the salient features of sugarcane breeding.

The flowering of the Coimbatore seedling canes in the Punjab is discussed with reference to any possible disadvantages from the flowering.

The technique employed in the breeding of an improved seedling cane for the Punjab is described in broad outline.

The very important role played by the Provincial testing stations in the breeding of improved canes for the different localities is described.

The need is indicated of a breeding station under Central Government for effectively raising the quality of canes under cultivation.

5. Correlation between yield and some prominent characters in *Andropogon Sorghum*.

Messrs. Kottur *and* Chavan, Dharwar.

Correlations between the yield of grain and seven characters of the stalks and ear are studied in *Andropogaon Sorghum* (Jowar)—four important varieties of Dharwar (South Bombay) being selected for the purpose. The correlations are positive and reliable in five and small and un-reliable in 2 cases. The length of the rachis and the breadth of the ear have high degree of correlation. The length of the rachis is easy to measure on the plant before flowering and this is mainly employed by the writers in their selection-work. It has supplied a satisfactory basis so far.

6. The yielding power of a strain of Mysore-American Cotton compared with that of Cambodia and Dhawar-American.

V. N. Ranganatha Rao.

Mysore-American is a form of Doddahatti that has been evolved by hybridising the local Dharwar-American with a tree-cotton answering to *G. Perivianum*. Two strains have been fixed and a study of yield on these strains has been made and compared with that of Cambodia and Dharwar-American.

(1) Number of vegetative and fruiting branches on the plant.
(2) Number of fruits on each of these branches and the total number of fruits on the plant as a whole.
(3) Shape and size of the fruit.
(4) Number of loculi per boll and the number of seeds per lock.
(5) Weight of lint per fruit.
(6) Weight of 100 seeds.

7. An attempt to introduce and acclimatise *Andropogon Sorghum*, Var. *technicus* (Broom-cord or Broom-corn in United Province) with seed introduced from N.-W. Italy (Ligurian Province) and the agricultural and industrial possibilities of Broom-corn cultivation.

S. S. Nehru.

The first paper on the subject was read at the Science Congress on January 8, 1926, and exhibits of Italian Broom-cord and Indian Sorghum were shown, as also experimental plants growing in a pot. These yielded a

small amount of seed which was sown and has permitted tests on a large scale. The results of these tests are discussed in detail.

8. The seasonal composition of well waters as a means of study of soil nitrification changes.

HAROLD F. ANNETT, Nagpur.

Investigations of well water composition in the black cotton soil tract at Nagpur have given interesting information regarding the changes taking place in the Nitrogen compounds of the soil. The results show that the excess nitrate formed in the soil passes into the subsoil water and there completely disappears. The loss of nitrate from this cause is shown to be equivalent to a loss of more than 1000 lbs. of nitrate of soda per acre, per annum. This rate of loss would mean that the whole of the nitrogen in the surface soil would be lost in about 44 years. The total nitrogen content has however remained constant over many years and this indicates that the nitrogen fixing powers of these soils are enormous. Incidentally it appears that the nitrogen lost as nitrate and the atmospheric nitrogen fixed must be approximately equal annually. The results are receiving fuller treatment elsewhere.

9. Seasonal variations of the nitrate content of soils.

H. N. BATHAM *and* S. NIGAM, Cawnpore.

The paper deals with the data obtained in different countries of the world regarding the seasonal variations of the nitrate content of soils along with those of the authors and the conclusions drawn are the following:—

1. That generally the greatest quantity of nitrates occurs in soils under different climates and treatments during the months of June, July, and October.
2. That the time of the year appears to be the most important factor in influencing the rate of formation and accumulation of nitrates in soils.

10. The effect of varying concentrations of ammonia on the nitrifying power of the soil.

D. V. BAL, Pusa.

Experiments on the effect of varying concentrations of ammonia on the nitrifying capacity of a soil are given.

From the results obtained it is seen that a concentration up to 60 mg. of ammoniacal nitrogen per 100 gms. of soil does not materially affect the process of nitrification but concentrations of over 100 mg. of ammoniacal nitrogen are definitely injurious to the process of soil nitrification.

11. An economical method of manuring with Sunn Hemp.

N. V. JOSHI, Pusa.

Field experiments have been carried on to show that Sunn Hemp can be used as a double purpose crop for getting green manure as well as fibre from it in one season. This can be accomplished by allowing it to grow for 12 to 14 weeks and cutting off its tops for green manure leaving the stems to be used as fibre. At this stage the tops from an acre of Sunn Hemp contain about 20 lbs. of Nitrogen but the comparative trials have shown that by manuring with tops, the outturn of succeeding crop is generally higher than the treatment with the whole plant, owing probably

to the rapid decomposition of the tops. In regions where crops are subject to attacks of white ants, manuring with tops has an additional advantage in that it leaves no undecomposed portions in the field and the succeeding crop is free from the attack of white ants. Where the whole plant is ploughed in, the crop is much damaged by white ants owing to undecomposed woody portions being left in the field. The fibre obtained from the stems of an acre of Sunn Hemp cut at 12 to 14 weeks is 4 to 6 maunds of fibre per acre.

The extra cost in using Sunn Hemp as a double purpose crop in the way suggested is the cost of cutting off the tops which amounts to Rs. 2 to 3 per acre.

12. Home made Super and its effect on Potatoes.

N. D. Vyas, Pusa.

(*a*) An easy and a successful method has been devised for the manufacture of super on one's own farm.

(*b*) The manure prepared by this method is superior to untreated phosphates or super.

(*c*) The yield of potatoes is increased by the Home made super to the extent of nearly 42% over control against 35% in the case of super and 12% in the case of sulphur free compost.

13. The effect of Sulphur oxidation on the microflora of activated sludge.

C. V. Ramaswami Ayyar *and* Roland V. Norris, Bangalore.

Suspensions of activated sludge alone and similar suspensions containing sulphur and sulphur and mineral phosphates were aerated for over a month and samples taken every 24 hours from which sub-cultures were made on (1) nutrient agar (2) wort agar and (3) a sulphur medium. The changes in p_H due to the oxidation of sulphur were also estimated. The influence of these changes on the numbers and nature of the bacterial population has been investigated.

14. Sulphur oxidising organisms from activated sludge, Part I.

C. V. Ramaswami Ayyar, Bangalore.

By aeration of an activated sludge suspension containing sulphur, acidity is rapidly developed due to the oxidation of sulphur and the p_H falls to about 2·1. At this stage the sulphur oxidising organisms are almost the sole survivors and their isolation comparatively easy. The cultural and physiological characteristics of an organism isolated in this way are described.

15. The production of ammonia by soil fungi.

A. K. Thakore *and* Roland V. Norris, Bangalore.

It is now known that fungi play an important part in the breakdown of nitrogenous organic matter in the soil. A study has been made of the production of ammonia by *Aspergillus flavus* and in particular the formation of ammonia from amino-acids and amides by an enzyme secreted by the organism. The conditions under which this enzyme functions have been investigated.

16. Aphids and Lady-bird beetles.

G. R. Dutt, Pusa.

Fighting insect-pests by means of their natural enemies is a very interesting line of work, and in India it has special advantages where the use of poisonous sprays cannot be safely recommended to the un-educated ryot. Cases are quoted where this method has been employed to control insect-pests in India, and details of an experiment are given where lady-bird beetles were successfully used in saving an experimental plot of lentils (*Ervum lens*) from a serious attack of Aphids.

17. Experimental control of sex ratio and its bearing on lac cultivation.

S. Mahdihassan.

Sex ratio among lac insects varies with seasons while the range of this variation differs with species. Among all species of lac insects it has been found that low moisture content of eggs before fertilisation leads to a favourable excess of females in the issuing progeny. For the same reason lac from trees growing on a hilly or heavily drained area gives a larger ratio of females. Lac should be grown on trees in two kinds of blocks, where the situation is dry and where it is wet. During monsoons lac must be grown on trees situated on the dry plots; during the non-monsoon season trees in the moist locality must be infected. This rotation will guarantee a better quality of brood lac (*i.e.* insuring a more favourable sex ratio) in one season, and maintains a more uniform yield of lac in the other.

18. The use of gypsum in the reclamation of Bara.

Mukand Lal, Lahore.

A brief description of Bara soil is given and the way in which the problem arose is described.

The theoretical considerations involved in the use of gypsum are discussed. The experimental work conducted so far is briefly described and the practical effects of different doses of the application of gypsum are indicated.

In the end the possibilities of gypsum as a reclamation agent of highly alkaline lands are discussed.

19. The fate of irrigation water and rainfall in the soil.

B. H. Wilsdon, Lahore.

The paper describes statistical analyses of records of rainfall and irrigation and their correlation with annual changes in the spring level. Regression equations are obtained showing the influence of the distribution of rainfall and irrigation on the changes observed. The physical significance of the empirical relations observed, and the connection with evaporative processes controlled by humidity and crops, is indicated. The possibility of determining the equilibrium conditions for a water table, with special reference to the inverse cases of irrigation by wells and canals, is discussed.

20. Mole Drainage.

B. H. Wilsdon, Lahore.

Experiments carried out in the Punjab with the Fowler Mole Drainage Tackle are described. Conditions for the successful application of the method in waterlogged soils with an arid climate are discussed.

21. Some studies on the growth of wheat plants and correlations between certain wheat characters, i.e., height of plant and length of head, etc., etc.

Jai Chand Luthra *and* Ranbir Singh, Lyallpur.

These investigations were made on three important wheats of the Province, 8A, Pb. 11, and Pb. 14. Results got from Pb. 11 were used for statistical studies.

Seed grains of each type were graded into three sizes, large, medium and small. Average height of plants raised from large grains was greater than that of those from small ones. Also the former ripen a little earlier than the latter.

Correlations:—These were worked out on Punjab 11. Height and number of grains per plant showed positive correlation. $r = \cdot 437 \pm \cdot 054$ in the case of large grains. Same was the result with height of plant and length of head.

Number of spikelets and height are positively correlated in plants got from the grains of all three sizes—Correlation between height and yield being $\cdot 474 \pm \cdot 0532$ is significant only in large grains

Sowing of large grains, therefore, is conducive to greater height of plants. These results however require corroboration by extended field trials. It would be interesting to discover how far weight of grain is associated with tallness.

22. Some observations on the extent of fertilization of ovules in various cottons.

Jai Chand Luthra *and* Sardar Khan, Lyallpur.

It is often noticed that a mature cotton boll contains a certain number of small undeveloped seeds, which are unfertilized ovules. The number of such ovules has been found to be variable in different types of cottons, viz., Punjab, American and Indigenous cottons which have been studied. Total number of ovules was counted and the percentage of those fertilized has been determined.

Number of loculi is variable even in the same type of cottons. Greater the number of loculi, the bigger the seeds.

Frequency distribution regarding the number of seeds set per boll has been studied. In the case of Indigenous cottons about 52 per cent. of the bolls examined contained all the seeds fully developed. In American Selection 285F only 26 per cent. of the bolls showed this.

Photographs of the seeds illustrate the difference between mature seeds and immature seeds or unfertilized ovules.

23. Experiments on Egyptian Cotton in Sind.

K. I. Thadani, Sind.

The experiments conducted at Dhoro Naro show that if Egyptian cottons are grown in April-May on soils free from salt, they are capable of giving high yield to the extent of 1500 lbs. of seed cotton per acre. They require to be watered at an interval of at least 15 days, or perhaps earlier. The Mitafifi and Ashmoni varieties were found most suitable. The staple of Yannovitch and Abassi, which had longer staple than Mitafifi and Ashmoni, was considerably affected under Sind conditions. The yielding capacity of the former was also less.

The experiments on the Mirpurkhas Farm showed that the Egyptian cottons have no possibilities on land impregnated with salt. The Sakrand experiments point in the same direction.

The experiments of 1926 have shown that Upper Egyptian cottons seem to thrive much better in Sind than the lower Egyptian types

which are as a rule finer and longer stapled. There are indications that the ginning percentage under Sind conditions seems to improve considerably, and the staple is somewhat reduced. One of the varieties has yielded about 1000 lbs. seed cotton per acre in the first picking at Matli. Ashmoni and Zagora have been so far found to be the most suitable. The final results are not yet ready at the time of writing.

24. A note on the mechanical analysis of soils.

AMAR NATH PURI *and* BHAILAL M. AMIN.

An improved form of pipette method of mechanical analysis of soils has been described and the various sources of errors discussed.

A comparative study has been made of the methods of preparation of the soil for the mechanical analysis. The results show that to obtain maximum dispersion of the soil, treatment with dilute HCl is necessary.

Treatment with H_2O_2 (New Official English method) or hot $\frac{N}{5}$ HCl (Hissink's method) is not necessary. $\frac{N}{20}$ HCl (cold) is quite effective in giving the maximum dispersion and is the least drastic.

25. Note on the hypothesis of "Unfree Water" in soils.

AMAR NATH PURI.

There is no such thing as "unfree water" in soils is the sense that Bouyoucos uses the term to mean i.e. that amount of water that does take part in dissolving the soluble salts.

The phenomena of negative absorption has been noticed in the case of soil and sugar solution and this seems to follow the same law as positive absorption so well known in colloid chemistry.

26. Base exchange capacity of soils and a new method for finding it.

A. N. PURI.

27. The value of Seed testing.

R. D. BOSE, Pusa.

Crop production even under the most favourable conditions is uncertain, depending on many factors, partially or wholly beyond the control of the cultivator. Agricultural advancement, as a matter of fact, is largely a matter of overcoming the factors of uncertainty. One of the chief factors in crop production that could be controlled fully is the quality of the seed planted. Good seed is essential to successful agriculture, and the economic importance of seed testing in this connection cannot be over-estimated.

The germination of seeds depends on a proper supply of heat and moisture, and to a certain extent darkness is also necessary. Seeds will germinate through a considerable range of temperature and humidity but the number of germinating seeds decreases as the conditions depart from the optimum. Examples are given to show how a simple germination test record could be maintained and facts and figures are quoted to show that a slight change in conditions brings about an enormous difference in the germinating capacity of seeds.

In India the supply of agricultural seeds of standard quality is at present practically restricted to various government agencies. These endeavour by careful selection and germination tests to maintain a uniform quality in the seeds they distribute, but there is no legal system of certification such as exists in some countries in Europe and in the

United States of America. There, Seed Laws require the vendors to furnish a written or printed label containing a statement specifying—(1) the commonly accepted name of the agricultural seeds; (2) the percentage by weight of purity, (3) the percentage of germination, and (4) the name and address of the vendor.

Seed testing and the Certification of Seed have now become matters of international interest. Results achieved in other countries suggest that Certification of Seed pays both the buyer and the vendor, and is certainly a great boon to the country as far as the control of weeds is concerned. The supply of agricultural seeds in India is the most important factor in the welfare of the greatest industry in the country and it is certainly advisable to adopt the methods which have proved beneficial in other lands.

28. The eradication of Kans (*Saccharum spontaneum* L.)

Albert Howard, Indore.

A method of eradicating *kans* has been worked out at Indore by which it is possible at small cost to get rid of this pest. The implement used is an adjustable *bakhar* capable of working to a depth of eight inches and drawn by two pairs of oxen walking abreast in a specially designed yoke. The cost of the complete outfit is Rs. 62 and the cost of a single ploughing is under five rupees an acre. This method of deep cultivation is suitable for the eradication of most deep-rooted weeds and also renders the use of tractors and steam ploughs unnecessary in many parts of India.

29. The mixing of cotton varieties.

Albert Howard, Indore, *and* S. C. Talesara.

Two possible causes of the mixing of cotton varieties on the black soils of Peninsular India have been investigated, namely, secondary flowering during the hot weather and the contamination of the soil by cotton seed fed to the work cattle. Both factors were found to be involved in the admixture of pure cultures.

30. A method of improving the feeding value of straw-chaff.

Albert Howard, Indore.

Recent experiments, carried out at the Institute of Plant Industry, Indore, show that it is possible materially to improve the feeding value of the dry stalks and chaff of wheat and *juar* before they are fed to cattle. The method consists in mixing the materials with five per cent. by weight of chaffed green maize or lucerne and allowing the mixture to ferment. The fermented straw chaff is much richer than ordinary chaff in albuminoids, sugar and digestible fibre and is more readily eaten by the work cattle.

31. Root development of Paddy under different conditions of growth.

Ram Lal Sethi.

Four different types of U.P. Paddy possessing early, late, fine and coarse characters were sown in pots under different manurial treatment. Dry weights of shoots and roots of the individual plants at different stages of growth were recorded and their shoot and root ratios were worked out. Corroboration of the results was obtained by growing one variety under similar conditions of growth in the field as well. Results are discussed from the point of view of the influence of different types of manuring on root growth as well as of other environmental conditions.

Section of Mathematics and Physics.

President :—Prof. D. M. Bose, M.A., Ph.D.

Presidential Address.

Some recent theories on Magnetism.

The subject of my present discourse is "Some recent theories on Magnetism." As you all know the phenomenon of magnetism though the earliest to be discovered is one about whose real nature very little is known.

The first great step in advance was taken by Ampere in 1820, when from his theory of the equivalence of closed electric current to a magnetic shell he drew the conclusion, that magnetism is not a new kind of phenomenon but is only due to the flow of closed electric currents through resistanceless circuits in each of the elementary particles out of which a magnetic body is made up. This electric current can either exist permanently or may be brought into existence by induction. It is found convenient to suppose that in such bodies elementary current elements exist whose intensities can be altered by the action of a magnetic field. We next find Weber in 1871, with the help of the recently discovered atomicity of electricity, developing the conception of Ampere, when he supposes that in every particle a positive charge rotates about a negative central charge. These fruitful ideas of Ampere and Weber were first put in a systematic form by Langevin in 1905, when he developed his electron theory of magnetic phenomena.

Of the three kinds of magnetism, ferromagnetism, paramagnetism and diamagnetism, the first, though earliest discovered, is least known and I propose to exclude this subject from my present discussion and confine myself entirely to the consideration of dia- and paramagnetism.

In this connection we have to define the magnetic susceptibility k per unit volume as the ratio of magnetic moment M per unit volume to the magnetising field H. If we multiply k by ρ the density of the substance we have the mass susceptibility χ and that multiplied by the atomic or molecular weight gives the atomic resp. molecular susceptibility χ_A *or* χ_M. For paramagnetic substances $\chi > 0$ and for diamagnetic substances $\chi < 0$.

Electron theory and its application to magnetic phenomena.—I give below some of the formulae derived from the electron theory, which have important bearings on all theories of magnetism. According to recent views, an atom consists of a con-

centrated positive nuclear charge round which a certain number of electrons are moving in closed orbits. If the area of an electronic orbit be S, and τ is the time taken by the electron to describe this orbit, then the angular moment of the electron = mass χ twice the area described per unit time

$$p = m \times \frac{2S}{\tau}.$$

On the other hand the magnetic moment μ of a current J flowing round the circuit enclosing an area S is $\mu = JS$; in the present case $J = \frac{e}{c\tau}$, where e is the charge on the electron in e.s. units; from which it follows

$$\mu = \frac{eS}{c\tau} = \frac{e}{2mc} \cdot p.$$

In general if I is the resultant of the mechanical moment of all the electrons in a piece of matter, and M the resultant magnetic moment, then $M = \frac{e}{2mc} I$.

Larmor's Theorem.—An electron moving in a closed circuit is placed in a magnetic field of strength H, the axis of the electronic orbit will then describe a precessional motion round the direction of H, with an angular velocity $O = -\frac{e}{2mc} H$. With the help of these formulae we will discuss some important phenomena in magnetism.

Magneto-mechanical effect.—When a rigid body is rapidly rotated about an axis, then on account of the above formula the following relation holds between the impulse moment and magnetic moment of the rotating body, $M = \frac{e}{2mc} I$. We can picture that each atomic axis performs a precessional motion O round the fixed axis of rotation, which can be neutralised by the creation of an external magnetic field parallel to the axis of rotation, such that $\frac{O}{H} = \frac{e}{2mc} = \frac{M}{I}$. Then each atomic axis will keep its direction fixed in space, or in the given body at rest such precessional motion O of the atomic axis can be brought about by a magnetic field of strength H parallel to the direction of I.

This experiment was first carried out by Barnett.[1] He

[1] For a connected account see Barnett "Angular momentum of the elementary magnet" in Bull. of National Council of Research, Vol. 3, Part 3, No. 18, p. 235.

measured the external magnetic field H which is necessary in order to produce the same magnetic moment M when the body is at rest. In all experiments carried out by Barnett and others it is found that $\frac{M}{I}$ is about double the above calculated value. These experiments are carried out in ferromagnetic bodies like Fe, Ni, Heuessler's alloy, etc. where the effect is best observed.

Another experiment first suggested by Richardson and later independently worked out by Einstein and de Haas, is the converse of the previous one. They measured the angular velocity O produced in a suspended rod of a ferromagnetic substance placed inside a solenoid carrying a magnetising current, when the direction of the latter is suddenly reversed. At first Einstein and de Haas thought that their experiments verify approximately the relation $\frac{M}{I}=\frac{e}{2mc}$, but later experiments by Stewart, as well as Beck and Arvidsson, and Chattock and Bates, show that the value found is double the theoretical one.[1]

The results of these two sets of experiments show that the value of $\frac{e}{m}$ as found by the experiments of Kaufmann, Bucherer and others is half of that found by these magnetomechanical effect. The only difference in the condition of experiment is that in the one case the electrons are free and in the other they are bound to atoms which are paramagnetic in nature. The question of the existence of electrons in which the ratio of $\frac{M}{I}$ is double the expected value has come into prominence in connection with the recent "spinning electron" hypothesis of Uhlenbeck and Goudsmit.[2] The orbit of an electron moving in a closed orbit round a nucleus can be described mechanically in terms of three quantum numbers nkj, where n is the total quantum number, k the azimuthal number and j the inner quantum number. The first two define the shape of the electron orbit while the last defines the inclination of the electron orbit with respect to the atomic axis. It has been found that many phenomena in connection with the fine structure, anomalous Zeeman effect, etc., of spectral lines cannot be completely described in terms of these variables alone, but in terms of four quantum numbers as proposed by Pauli, Heissenberg and others. This has led Bohr to postulate the existence

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[1] For references see Handbuch d. Radiologie, Vol. 6, p. 735.
[2] Nature, Feb. 20, 1926, p. 264.

of certain non-mechanical double sidedness in inter-atomic phenomena which cannot be described in purely mechanical terms. Uhlenbeck and Goudsmit have introduced a fourth variable in the characterisation of a bound electron, by supposing that a bound electron besides possessing angular momentum due to its orbital motion has another momentum due to the spin of the electron round an axis of its own. For this spin the ratio of $\frac{M}{I}$ is assumed to be $\frac{e}{mc}$, while for the orbital motion the ratio is $\frac{e}{2mc}$. With the help of this hypothesis these two authors have been able to give a qualitative explanation of the difference between the screening and relativity doublets in X-ray spectra, of anomalous Zeeman effect, etc. I understand that certain experiments are being undertaken by de Haas to find out whether a free electron has a magnetic moment due to the presence of a spin round an axis.

Diamagnetism.—In the phenomena of diamagnetism we have, on the other hand, evidence that the ratio of $\frac{M}{I}$ of an electron due to its orbital motion has the value $\frac{e}{2mc}$ as given by the classical electron theory.

When the different electronic orbits are so oriented in an atom that the resultant mechanical and magnetic moments are each equal to zero, such an atom when placed in an external magnetic field has a magnetic and consequently mechanical moment produced by electromagnetic induction. According to Larmor's theorem, the electron describes a precessional angular velocity $\omega_z = -\frac{e}{2mc}H$ round the magnetic axis which we now take to be the z-axis. The increase in angular momentum due to this,

$$\Delta I_z = \Sigma m_i \overline{r_i^2} \,.\, \omega_z = \omega_z \Sigma m_i (\overline{x_i^2 + y_i^2}).$$

Then
$$\Delta I_z = -\frac{eH}{2c}\Sigma(\overline{x_i^2} + \overline{y_i^2}),$$

and the resulting magnetic moment

$$\Delta M_z = \frac{e}{2mc} \,.\, \Delta I_z = -\frac{e^2 H}{4mc^2}\Sigma(\overline{x_i^2} + \overline{y_i^2})$$

$$= -\frac{e^2 H}{6mc^2}\Sigma\overline{r_i^2}\,;\ \text{since } \overline{x_i^2} = \overline{y_i^2} = \overline{z_i^2} = \frac{\overline{r_i^2}}{3}$$

where $\overline{r_i^2}$ = mean of the square of the radius of the orbit of the i^{th} electron. If there are n atoms per unit mass of the substance then the mass susceptibility

$$\chi = \frac{M}{H} = \frac{n \times \Delta M_z}{H} = -\frac{ne^2}{6mc^2} \Sigma \overline{r_i^2}$$

and the atomic susceptibility

$$\chi_A = -\frac{Ne^2}{6mc^2} \Sigma \overline{r_i^2}.$$

From this we can deduce certain important conclusions :—

(i) Since the atomic orbits are very little affected by heat motion, therefore the diamagnetic susceptibility is independent of temperature and pressure—a fact which has been experimentally verified by Curie and others. Recent experiments of Glaser to be described below appear to contradict this.

(ii) In any compound, in which an atom enters, only the peripheral orbits are slightly affected by such combinations while the inner orbits are totally unaffected. If that is the case then the diamagnetic molecular susceptibility of a compound can be calculated from a knowledge of the atomic susceptibilities of its constituent atoms. This law was first discovered by Pascal. He gives the following values for the atomic susceptibilities of

$$\chi_A$$
$$H = -2\,93 \times 10^{-6}$$
$$C = -6{\cdot}00 \times 10^{-6}$$
$$O = -4{\cdot}61 \times 10^{-6}$$
$$Cl = -20{\cdot}1 \times 10^{-6}$$

from which the molecular susceptibility of ethyl alcohol can be calculated

$$\chi_M \text{ of } C_2H_5OH = -(2 \times 6{\cdot}00 + 5 \times 2{\cdot}93 + 7{\cdot}54) \times 10^{-6}$$
$$= -34{\cdot}2 \times 10^{-6}$$

Experimentally found χ of $C_2H_5OH = -30{\cdot}5 \times 10^{-6}$

Glaser's experiments.—Recently Glaser [1] working in Wien's laboratory has determined the diamagnetic susceptibility of a large number of gases at different pressures. He found that in the gases CO_2, N_2, H_2 the curves connecting the volume susceptibility with pressure are linear at higher and lower pressures with an intermediate connecting portions (see Fig. 1). The proportionality factor between the susceptibility and pressure is approximately three times as great for all gases at the lower pressures, which means that the molecular susceptibility is three times as great also. Glaser explains this surprising result by supposing that in a magnetic field even diamagnetic mole-

[1] Phys. Zeit. 26, 212, 1925.

cules tend to orient themselves. This orientation is disturbed by collisions and that it is not instantaneous, but only occurs completely when the time required is short compared with the mean time between collisions. The critical pressure is smaller the higher the molecular weight, being at 4700 gauss 610, 410, 310 mm. for H_2, N_2, CO_2; suggesting that the time required for orientation is greater, greater the moment of inertia of the molecule. Glaser's experiments have given rise to a large amount of discussion and many people have started repeating his experiments. In a recent paper in the Annalen der Physik (81, 229, 1926) Erwin Lehrer has determined the variation in the susceptibilities of different gases as functions of temperature

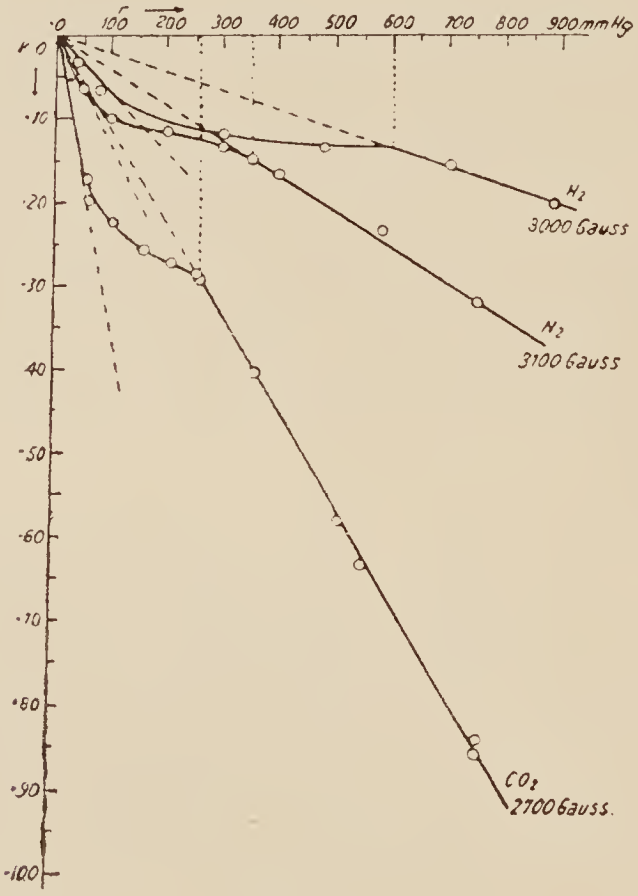

Fig. 1.

and pressure by a method first suggested by Einstein. He finds that for CO_2, Ar, H_2 within a range of 0° to 250°C, the diamagnetic susceptibility is independent of temperature. He next investigated the difference in volume susceptibility k in a gas produced by a difference in temperature for a number of gases between the pressures of 60 to 720 mm. He found that in all of them the volume susceptibility is proportional to the pressure within an accuracy of 1%. An anomaly for the diamagnetic gases as found by Glaser could not be verified. Recently Hammar, (Proc. Nat. Am. Acad. Oct.1926) who employed the same method as Glaser, found the mass susceptibility of these gases to be independent of pressure between 0 aud 760 mm. In Glaser's experiment what is actually measured

is the difference in the susceptibility of a glass rod from that of the surrounding gas in which it is immersed at different pressures. Hammar explains the anomalous results found by Glaser by supposing that in Glaser's experiment there was a film of moisture absorbed by the surface of the glass rod, which evaporated at low pressure and thus produced a change in the difference of susceptibility between that of the rod and the surrounding gas. The subject is still obscure and requires further elucidation. My colleague Dr. P. N. Ghosh has tested an optical consequence of Glaser's hypothesis of the orientation of gas molecules in a magnetic field. Such an orientation is sure to produce an alteration in the R.I. of the gas under the influence of the magnetic field. Dr. Ghosh believes that by a delicate optical test he has found that R.I. of CO_2 does alter in the range below 300 mm. in confirmation of Glaser's result.

Reverting back to the formula for the atomic susceptibility of a diamagnetic gas

$$\chi_A = -\frac{Ne^2}{6mc^2}\Sigma\overline{r_i^2}$$

we can write $\pi\Sigma\overline{r_i^2} = Z_i S_i$, where Z_i is the number of electrons with orbits of area S_i and $Z = \Sigma Z_i$ the atomic number of the given element.

Then
$$\chi_A = -\frac{Ne^2}{6\pi mc^2} \cdot \Sigma Z_i S_i$$

or
$$\bar{S} = \frac{1}{Z}\Sigma Z_i S_i = \frac{6\pi mc^2}{Ne^2} \cdot \frac{\chi_A}{Z} = 1{\cdot}103 \times 10^{-10}\frac{\chi_A}{Z}.$$

Thus from a knowledge of atomic susceptibility it is possible to calculate the mean area (also radius) of the electronic orbits in different atoms and ions. From this Cabrera[1] calculates the area of the outermost electronic shell of different gases and ions with help of the following formula, which for Argon is as follows :

$$18\,\bar{S} = 2(S_K)_{He} \cdot \left(\frac{2}{Z}\right)^2 + 8(S_L)_{Ne}\left(\frac{8}{Z-2}\right)^2 + 8(S_M)_{Ar}\left(\frac{8}{Z-10}\right)^2$$

and from that
$$r_A = \sqrt{\frac{\bar{S}}{\pi}}.$$

In this way Cabrera has calculated the atomic diameters of the noble gases and compared their values with those obtained by Grimm and Herzfeld by extrapolation from the diameters of cations and anions of halogen alkali compounds as deduced from X-ray spectra.

From the expression $\frac{1}{2}d = \alpha r_a + \beta r_c$ where r_a and r_c are the

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[1] Cabrera, Journ. d. Phys. et Rad. Vol. 6, p. 247, 1926.

radii of the anion and cation and α and β are two constants, while α is determined from X-ray data.

Thus for all ions having the argon structure we find

	P^{---}	S^{--}	Cl^{-}	Ar	K^{+}	Ca^{++}	
$r_A \times 10^8$	1·37	1·13	0·98	0·85	0·76	0·69	.. Magnetic data.
	..	1·09	0·95	0·87	0·79	0·67	.. Grimm Herzfeld Fajan.

For the Neon type

	N^{---}	O^{--}	F^{-}	Ne	Na^{+}	Mg^{++}	
$r_A \times 10^8$	0·77	0·65	0·55	0·54	0·43	0·39	.. from magnetic data.
	..	0·89	0·75	0·63	0·52	0·39	.. Fajan and Herzfeld.

and for the inert gases

	He	Ne	Ar	Kr	Xe	
$r_A \times 108$	0·57	0·54	0·85	1·03	1·44	.. from magnetic data.
	..	0·63	0·87	0·97	1·10	.. Grimm and Herzfeld.

Considering the entirely different methods of calculation used, the agreement is extraordinarily good. This I think gives a proof of the correctness of the relation $\frac{M}{I}=\frac{e}{2mc}$ which has been used in calculating the atomic radii from the value of the diamagnetic susceptibility. Thus we find, that so far as we are concerned with diamagnetic phenomena, the ratio of $\frac{M}{I}$ is equal to $\frac{e}{2mc}$ as required by the classical theory, while on the other hand when calculating the magneto-mechanical effects in paramagnetic substances, the value of $\frac{M}{I}$ has to be taken as equal to $\frac{e}{mc}$ the same as for spinning electrons.

Paramagnetism.—The fundamental experimental fact on which Langevin's Theory of Paramagnetism is based is Curie's classical experiments on the temperature variation of mass susceptibility of oxygen. Curie found that over a large range of temperature 290° to 580°A.

$$\chi T = \text{constant.}$$

To deduce the above relation Langevin assumed that each molecule of oxygen has a magnetic moment μ, and that in the absence of a magnetic field the magnetic axes of such molecules are randomly oriented. When a magnetic field is created, the

molecules try to place themselves parallel to the field but are prevented by molecular collision. Applying Boltzmann's theorem we find that if $\overline{m}$ average magnetic moment per molecule at temperature T in a field of strength H

$M=N\overline{m}$ the magnetic moment per gm. molecule under given condition.

$M_0=N\mu$ the magnetic moment per gm. molecule when all the molecules are oriented parallel to one another,

then
$$\frac{\overline{m}}{\mu}=\coth x-\frac{1}{x}=L(x)\,;\ \text{where } \chi=\frac{\mu H}{kT}$$
$$=\frac{x}{3}-\frac{x^3}{45}+\ldots.$$
$$=\frac{x}{3}\ \text{for small values of } x$$
$$=\frac{\mu H}{3kT}\,;$$
$$\overline{m}=\frac{\mu^2 H}{3kT}\,;\ \overline{M}=\frac{{M_0}^2}{3RT}\cdot H$$
$$\chi_M=\frac{\overline{M}}{H}=\frac{{M_0}^2}{3RT}$$

or
$$\chi_M T=\frac{{M_0}^2}{3R}$$
$=C$; Curie's constant. This is Langevin's formulation of Curie's law, from which it follows that $M_0=\sqrt{3RC}$.

In general it can be shown that for small values of $x=\frac{\mu H}{kT}$;

$$\chi_M T\frac{{M_0}^2}{R}\,\overline{\cos^2\theta}=\alpha\frac{{M_0}^2}{R}\,;$$

when $\alpha=\overline{\cos^2\theta}$ average value of the square of the cosine of the orientations of the gas molecules in the magnetic field.

In the classical theory of statistical mechanics all directions of orientation are equally probable the value of $\overline{\cos^2\theta}=\frac{1}{3}$, but according to the quantum theory it may have different values. This point will be considered later.

Curie found that Langevin's formula holds good not only for gases, but also for dilute solutions of paramagnetic salts and

even for crystalline powders; but in the latter case a certain empirical modification of Langevin's formula is necessary, viz.

$$\chi_M = \frac{c}{T-\Delta}.$$

This empirical formula was first developed by Weiss, who found that in ferromagnetic substances at sufficiently high temperature the susceptibility can be represented by a formula of the above type, and he gave the following interpretation of Δ.

In deducing Langevin's formula it is assumed that the magnetic molecules are so far away from one another, as to be outside each other's influence. But in the case of concentrated solutions and crystalline powders this assumption is not true and the effective magnetic field acting is $F = H + \nu m$

where m = the magnetic moment per unit volume of the substance.
= the intensity of magnetisation; ν is a constant factor.

In that case

$$m = n\alpha \frac{\mu^2}{kT}(H + \nu m);$$

where n = number of atoms per unit volume

$$m = \frac{n\alpha\mu^2}{k\left(T - \frac{n\alpha\nu\mu^2}{k}\right)} H$$

$$= \frac{n\alpha\mu^2}{k(T-\Delta)} H;$$

where
$$\Delta = \frac{n\alpha\nu\mu^2}{k} = \frac{n\alpha\nu}{k}\left(\frac{M_0}{N}\right)^2$$

$$= \frac{n}{N} \cdot \alpha \cdot \frac{M_0^2}{R}\nu$$

$$= c.\frac{\rho}{W} \cdot \nu;$$

where ρ = density,
W = molecular weight of the substance

Or,
$$\frac{M}{H} = \frac{\alpha N\mu^2}{k(T-\Delta)} = \alpha \cdot \frac{M_0^2}{R(T-\Delta)}$$

$$\chi_M = \frac{c}{T-\Delta}; \quad c = \frac{\alpha M_0^2}{R}.$$

We shall now proceed to discuss the following :—

(i) How far has Langevin's formula been experimentally tested, i.e. (α) whether for small values of $x = \frac{\mu H}{KT}$ the relation

$\chi_M T = c$ holds, and (β) for large values of x, whether the general formula of Langevin $\frac{\bar{m}}{\mu} = \coth(x) - \frac{1}{x}$ is verified ?

(ii) What experimental verification there is of Weiss's hypothesis of the origin of the correction term Δ, and is there any evidence which goes against Weiss's hypothesis ? If so, what alternative explanations have been offered to account for the origin of Δ.

(iii) Criticism and experimental test of Langevin's hypothesis of the orientation of the magnetic molecules in an external field. Discussion of alternative explanation and their experimental test.

I. Experimental verification of Langevin's formula.

(α) For small values of x.

The results of experiments on oxygen is shown in fig. 2. Curie's observations extended from about 290° to 580°A., and his results can be represented by $\chi = \frac{\cdot 0307}{T}$, while Kammerling Onnes and Oosterhuis' measurements on the gas at 100 Atmosphere between 170° and 290°A. fit the formula $\chi = \frac{\cdot 0306}{T+2}$ or

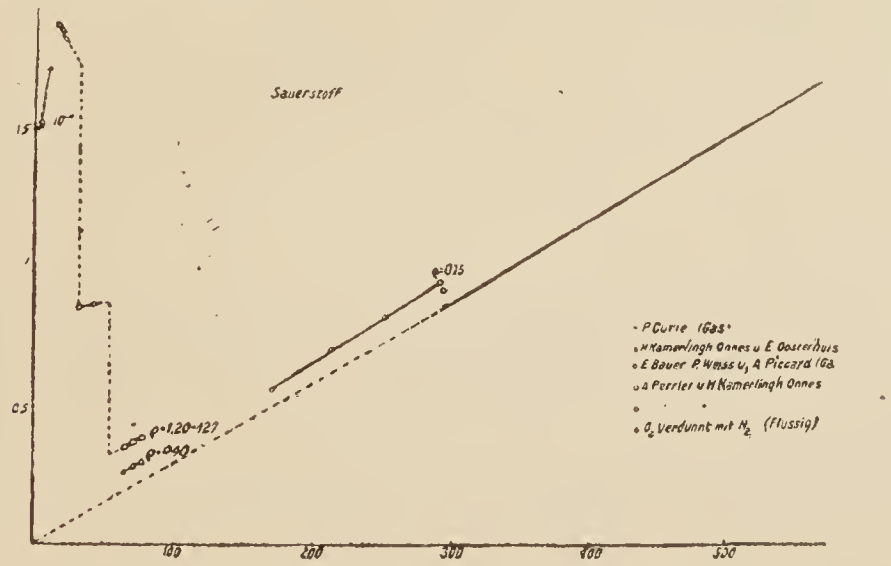

FIG. 2.

approximately a formula with $\Delta = 0$. The second substance chosen by Onnes for experiment was $Gd_2(SO_4)_3, 8H_2O$. This substance has a high susceptibility and the distance between the Gd^{+++} ions is large so that the Δ term is expected to be negligible. For this substance Onnes found that down to 20°A. Curie's law was strictly verified.

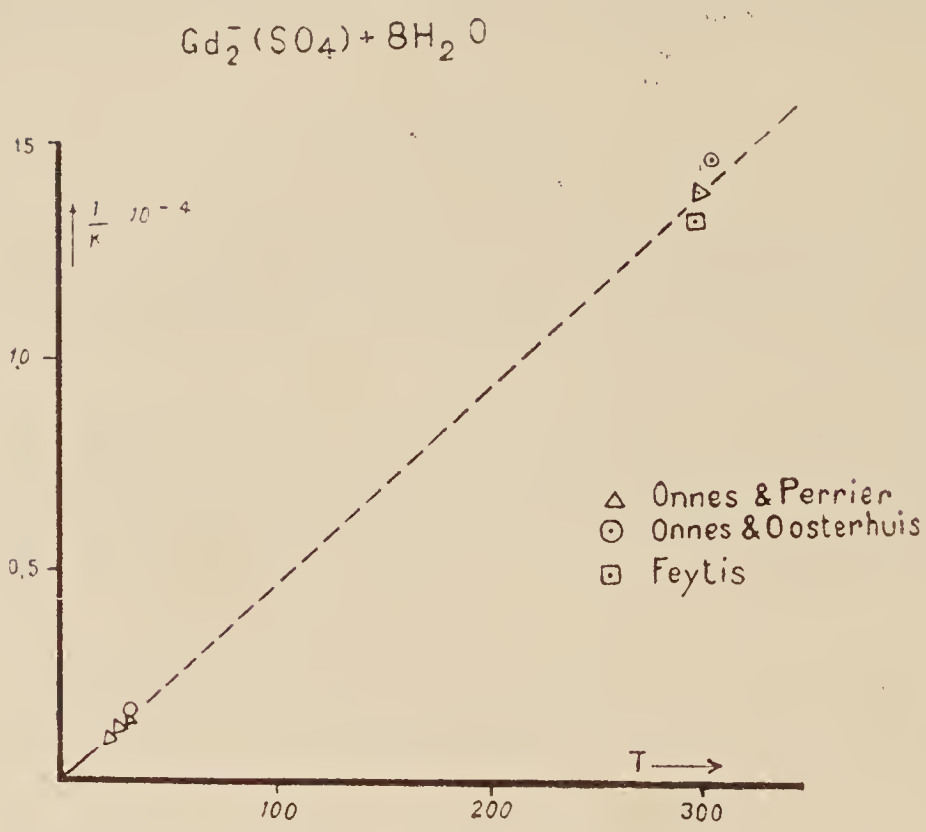

FIG. 3.

(β) For stronger fields and for temperatures between 4·25 and 1·9 A., Onnes found that in the above substance the susceptibility is no longer proportional to the field strength.

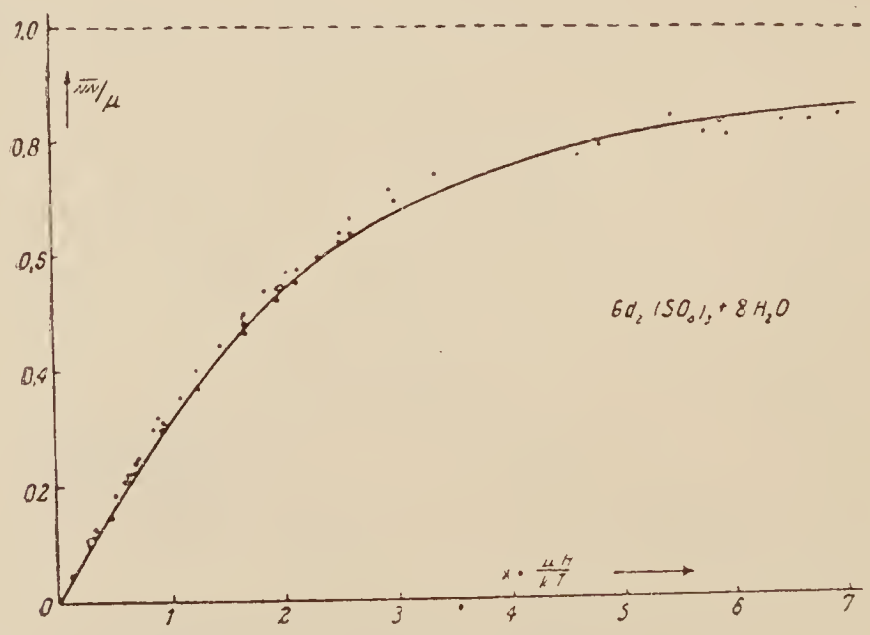

FIG. 4.

In fig. 4 the last six points are determined for temperature between 20°·42 – 13°·90 A., and the last two points on the right at 1·31 A. and in a field of strength 22,000 Gauss. The points, according to Kammerling Onnes, lie on the Langevin curve $\frac{\bar{m}}{\mu} = \coth x - \frac{1}{x}$, which is represented by the drawn figure. At

the lowest temperature a maximum saturation of 84% is reached.

These experiments have been further carried out by Wolter who has found that for anhydrous $CrCl_3$, $CoCl_2$, $NiCl_2$ Δ is positive, with values 32°·5, 20°, 67° respectively. Thus in the region of liquid air temperature they show susceptibility dependent on field strength. For $CrCl_3$ the susceptibility decreases while with the other two it increases with field strength.

Thus in this region $CrCl_3$ shows ferromagnetism.

II. Experimental verification of Weiss's Theory of the origin of Δ.—Experiments were performed with mixtures of

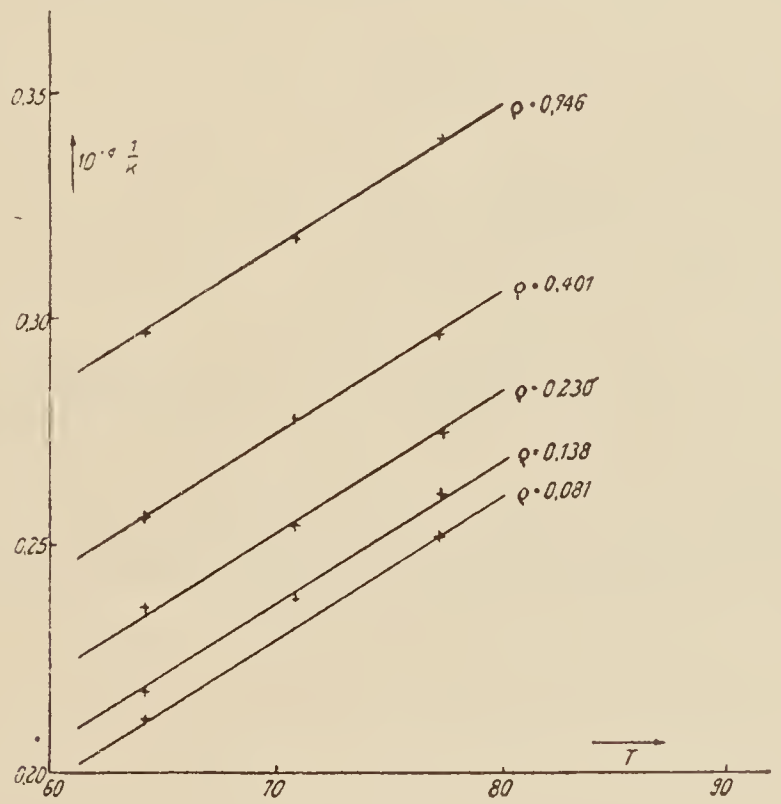

FIG. 5.

liquid O_2 and N_2 by K. Onnes and Perrier, in which the density of liquid O_2 varied from $\rho = \cdot 081$ to $\rho = \cdot 746$.

It was found that the experimental results could be represented by

$$\chi = \frac{c}{T - \Delta} = \frac{0{\cdot}0315}{T - \Delta}.$$

The accompanying table gives the values of Δ for different values of ρ :—

ρ	Δ
0·081 –	2·2
0·138 –	4·5
0·230 –	9·5
0·401 –	16·3
0·746 –	29·5

It is found that $\Delta = -40\rho$, and $\nu = -1270$ is independent of density. Since Δ is negative it means that in liquid O_2 a negative molecular field is present.

Lastly Weiss's law has been verified for a few solid salts of which here examples are given of

(i) $MnSO_4$ and (ii) $MnSO_4$, $4H_2O$.

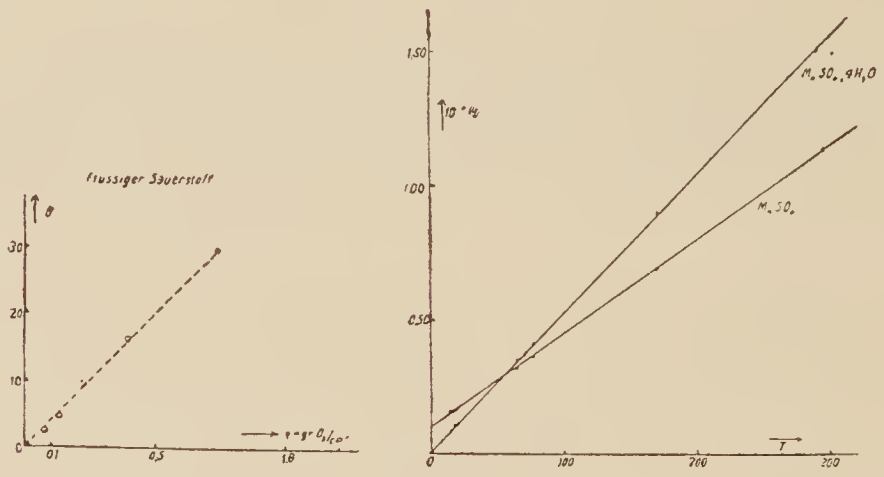

FIG. 6.

In fig. 7, for (i) $\chi = \dfrac{0{\cdot}0283}{T+28{\cdot}3}$ and (ii) $\chi = \dfrac{0{\cdot}0192}{T+1{\cdot}1}$.

Here the important fact comes out that by increasing the distances between the Mn^{++} ions by the addition of water of crystallisation the value of Δ is diminished as in the case of O_2.

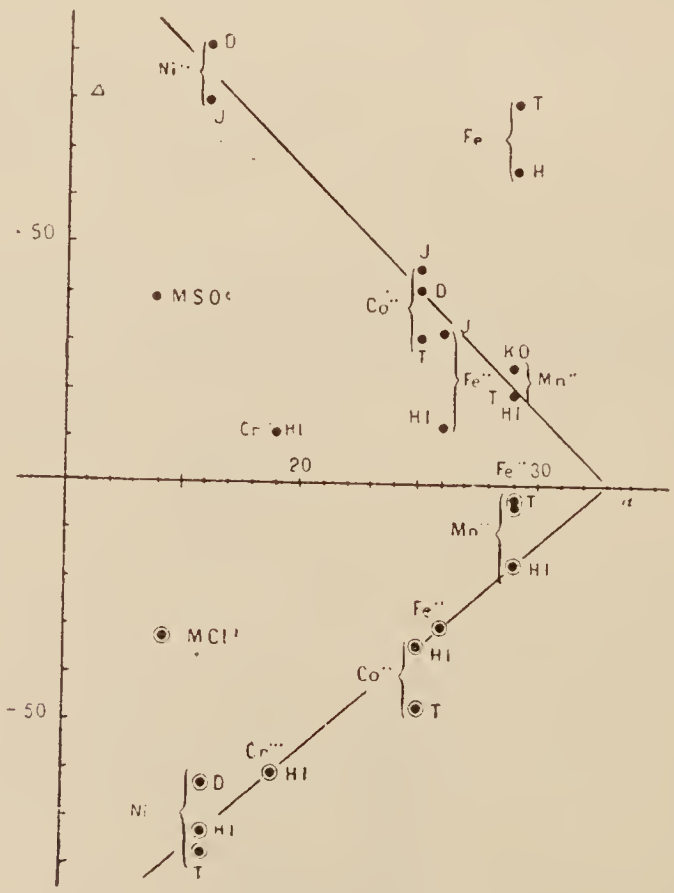

FIG. 7.

Criticism of Weiss's theory.—Since $\Delta = \frac{n\alpha v}{k}\mu^2$ the value of Δ ought to increase with μ, i.e. if we take the same kind of compound of the different paramagnetic atoms, the value of Δ ought to increase with the increase in atomic susceptibility. Cabrera[1] has shown that both in the case of the rare earth compounds and the first transition group of elements the value of Δ changes in the reverse order (see fig. 7).

Further, for salts in the solid state in the case of chlorides Δ is $> O$ and for sulphates Δ is $< O$. In the case of dilute solution of these salts Cabrera and Duperier[2] have shown that in solutions of $MnCl_2$, $Mn(NO_3)_2$, $NiCl_2$ to a large extent the value of Δ is independent of dilution

E.g., for $MnCl_2$:	Δ	$M_n(NO_3)_2$:	Δ
With 3·028 gms. of salt in 100 c.c. of water	$= -27{\cdot}8$	With 6·42 gms. of salt in 100 gms. of water ..	$= -21{\cdot}9$
With 15·035 gms. of salt in 100 c.c. of water	$= -25{\cdot}0$	With 36·9 gms. of salt in 100 gms. of water ..	$= -27{\cdot}0$
With 37·9 gms. of salt in 100 c.c. of water	$= -24{\cdot}0$		

Speculations over the origin of the molecular field.—According to Weiss's theory Δ ought to be always $> O$ while in the case of O_2 we have found it to be negative Further, in the equation $F = H + \nu m$, the value of ν according to theoretical considerations ought to be $\frac{4\pi}{3}$ while in the case of O_2, ν is found to be -1270.

Both Weiss and Debye have sought to explain the large value of Δ on the assumption that in a molecule along with the magnetic doublet μ_m is associated an electric doublet μ_e directed parallel to one another. In that case Δ is proportional to the work done in orienting the electric moments of the molecules parallel to the direction of H.

If the ratio of electric to magnetic polarisation be $\frac{P}{M} = \frac{\mu_e}{\mu_m}$ then the potential energy A of an element any particle when the magnetic polarisation is negligible is :—

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[1] Cabrera, Journ. d. Phys., Vol. VI, p. 285, 1925.
[2] Cabrera and Duperier, Journ. d. Phys., Vol. VI, p. 132, 1925.

$$A = \mu_m H + \mu_e \frac{4\pi}{3} P = \mu_m H + \frac{4\pi}{3} \frac{\mu_e^2}{\mu} M$$

and $$F = H + \frac{4\pi}{3}\left(\frac{\mu_e}{\mu_m}\right)^2 M \text{ ; thus } \nu = \frac{4\pi}{3}\left(\frac{\mu_e}{\mu_m}\right)^2$$

According to Debye $\mu_e \sim 10^{-18}$ and $\mu_m \sim 10^{-20}$, from which it follows that $\nu \sim 10{,}000$.

It is at least of the same order of magnitude as the value of ν found for O_2. But according to theory ν ought to be $> O$, while for O_2 $\nu < O$. On the other hand it has been found that for O_2, the index of refraction $n = \sqrt{\epsilon}$; which shows that the oxygen molecule is not an electric doublet, and therefore there is no justification for assuming that the origin of Δ in O_2 is due to the presence of electric doublets. This hypothesis of Weiss and Debye, as to the association of an electric with a magnetic doublet, has suggested some interesting experiments which we will consider when discussing Langevin's orientation hypothesis.

To summarise what has been said above about the origin of the molecular field we find that

(*i*) in certain cases Δ is due to a molecular field whose intensity diminishes with the increase of distance between the magnetic particles.

(*ii*) in no case can it be definitely attributed to magnetic origin.

(*iii*) in the examples cited by Cabrera, it is found that in the solid salts the sign and magnitude of Δ depends upon the nature of the anion. Further in dilute solutions Δ is independent to a large extent of the degree of dilution.

This has led Cabrera to suppose that the origin of Δ must be due, at least in certain cases, to the distortion of the external electron orbits to which the magnetic moment of the ion is due, by either the anion in the case of the solid salts, or by the associated water molecules in the case of the dilute solutions. The effects of the distortion of electron shell, in the cations and anions of different salts, have been studied by Fajan, Herzfeld and others, and a large number of properties of such compounds have been attributed by them to this cause.

Another obscure phenomenon which may find its explanation on this hypothesis, is the fact that the apparent atomic susceptibility of many magnetic salts varies with the degree of dilution and also with the increase in the H^+ concentration.

III. Criticism and interpretation of orientation hypothesis of Langevin.—According to Langevin, the O_2 molecules are supposed to orient themselves as a whole in the external magnetic field, with the direction of their magnetic axes distributed according to statistical laws in respect to the external field. If

we consider the molecule to consist of certain electrons moving in closed orbits round the nuclear positive charge, then as we have seen above, the electrons in their orbits will perform precessional rotation round the magnetic axis, and there will be no tendency for these orbits to place themselves perpendicular to the magnetic axis. Therefore there is no reason to expect that the atoms or molecules as a whole will tend to orient themselves in the magnetic field. Even when we assume that much orientation can take place in a paramagnetic solution, difficulties arise when we try to apply the conception to a paramagnetic crystalline solid, where such orientation of molecules as a whole is not possible. According to X-ray analysis of crystal structure we know that the ions of salt molecules are arranged in regular space lattices which keep fixed positions with respect to one another. If to avoid difficulties we assume that only the paramagnetic cations can rotate in a magnetic field then we invite fresh ones. For according to the kinetic theory the average rotational energy per each degree of freedom $=\frac{1}{2}kT$, and it ought to make itself felt in the sp. heat of the substance. And we know also from experience that in monoatomic gases there is no heat energy associated with rotation—and in the salts the ions behave like atoms.

At the suggestion of Debye a number of experiments have been undertaken to test the electrical consequences of the rotation hypothesis. If a molecule has both electric and magnetic moments, and their axis have fixed orientation with respect to one another, then if an orientation of the molecules in a magnetic field does take place, a resultant electric polarisation of the gas as a whole will be observed.

If $\overline{m}_e$ represents the average electric polarisation of a group of gas molecules, whose electric and magnetic moments are respectively μ_e and μ_m it can be shown that the resulting electri-polarisation in a magnetic field is

$$P=n\,.\,\overline{m}_e=n\,.\,\frac{\mu_e\mu_m}{3kT}\cos\alpha\,.\,H$$

where n=no. of molecules per c.cm.

α=angle between the directions of μ_e and μ_m.

This polarisation will induce an electric charge of surface density $\sigma=P$ on the two plates of a condenser immersed in the gas, and the resulting difference in potential expressed in volts is

$$V=300\,.\,\frac{A}{C}\,.\,n\,.\,\frac{\mu_e\mu_m}{3kT}\cos\alpha\,.\,H$$

where A=area of plates

C=capacity of condenser plates

Huber[1] has performed an experiment with NO gas which, is known to have both electric and magnetic moments. With a value of $H = 1500$ and assuming α to be zero it was calculated that $V = 72 \times 10^{-3}$ volts. With an electrometer of volt sensibility 8—10 scale divisions per 10^{-3} volt, no deflection was observed. Similar experiments with negative results were performed with $FeCl_3$ vapour, liquified NO and solid $Gd_2\ (SO_4)_3, 8H_2\ O$. This experiment though very important does not decisively prove that there is no orientation of paramagnetic gas molecules in a magnetic field

e.g. it may be that $\alpha = \frac{\pi}{2}$, but that cannot be in every case.

Gerlach [2] and Schutz have tried for years to detect magneto-optical phenomena in gases which depend upon the orientation of atoms in a magnetic field *e.g.* magnetic rotation of plane of polarisation and magnetic double refraction. Suppose we take the example of H_2 molecules in a magnetic field, in which all the atoms are so placed that axes of the electron orbits are parallel to the magnetic field. If ordinary light is transmitted through the gas, then the electric vector perpendicular to the magnetic field which displaces the electron in its own orbit, will travel much more quickly than the electricvector parallel to the field which has to displace the electron out of its own plane. The magnetised H_2 gas molecules must thus be double refracting, and the refraction should be independent of the wavelength and field strength. We exclude here from our consideration, the rotation and double refraction in the neighbourhood of absorption lines, which are a consequence of anomalous refraction in combination with Zeeman effect, and can be observed in alkali vapours with a field of 0·1 Gauss (Rotation only).

Schutz has used powerful apparatus to test the presence of this effect. He has used both paramagnetic and diamagnetic gases and vapours like air, O_2, CO_2, CS_2, Nitrobenzol, Argon over large range of pressure and with magnetic field of strength up to 15,000 Gauss, without finding any trace of double refraction. The apparatus used was so sensitive that a difference in components of the refractive indices of the order 6×10^{-9} for Na and K, and 3×10^{-10} for the remaining gases would have been detected. Thus we have not found any positive evidence of orientation of gas molecules in a magnetic field, so far as they can be tested by indirect evidence. To this class of experiment also belong the one performed by Weatherby and Wolf [3] who by a heterodyne method investigated the change in capacity of a condenser filled with one of the given gases He (20 cm.), Air (76 cm.), O_2 (76 cm.) when a magnetic

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[1] Huber, Phys. Zeit. 27, 619. 1926.
[2] Gerlach, Phys. Zeit 26, 819, 1925.
[3] Weatherby and Wolf, Phys. Rev., Vol. 27, 1926.

field of value 7—8000 Gauss was switched on. The experiment showed no change in dielectric constant of these gases within one part in 500,000. On the other hand reference has already been made to the recent results obtained by Dr. P. N. Ghosh with CO_2, in which he seems to find a change in the R.I. of CO_2 gas in the region of pressure which coincides approximately with that in which Glaser discovered a change in the atomic susceptibility of this gas.

The orientation hypothesis of Langevin meets its greatest criticism from the validity of Curie Langevin's law $\chi=\frac{c}{T-\Delta}$ for solid salts. It is interesting to note that Debye has applied Langevin's idea to explain the variation of dielectric constant with temperature. It is found that the dielectric constant can be represented by the formula $\epsilon=a+\frac{b}{T}$ where the first term represents the polarisation of molecules brought forth by an external field (analogous to diamagnetism) and the second term represents the effect of permanently polarised molecules, which orient themselves in an electric field (corresponding to paramagnetism). Further it is found that in solid dielectric the second term is absent, a fact to be expected if Langevin's orientation hypothesis is true. Thus it seems that the true application of Langevin's theory lies in paraelectricity and not in paramagnetism.

Alternatives to Langevin's Theory.—We give here some account of the attempts that have been made to explain Curie's law without assuming the free rotation of the magnetic molecules.

(i) Lenz supposes that the magnetic moment of a particle is so related to its position of equilibrium that the potential energy in diametrically opposite directions θ and $\pi-\theta$ with respect to a fixed direction is the same. While for any other deviations the potential energy called forth is so great that according to statistical principles they do not occur. So that we have only to take into consideration two equally probable diametrically opposite directions of the magnetic particles.

In a magnetic field of strength H

$$\frac{\overline{m}}{\mu}=\frac{\cos\theta e^{+\frac{\mu H}{kT}\cos\theta}+\cos(\pi-\theta)\; e^{\frac{\mu H}{kT}\cos(\pi-\theta)}}{e^{\frac{\mu H}{kT}\cos\theta}+e^{\frac{\mu H}{kT}\cos(\pi-\theta)}}$$

$$=\cos\theta\,.\,\frac{e^{\frac{\mu H}{kT}\cos\theta}-e^{-\frac{\mu H}{kT}\cos\theta}}{e^{\frac{\mu H}{kT}\cos\theta}+e^{-\frac{\mu H}{kT}\cos\theta}}$$

for the special case when $\theta=0$

$$\frac{\overline{m}}{\mu}=\frac{e^{\frac{\mu H}{kT}}-e^{-\frac{\mu H}{kT}}}{e^{\frac{\mu H}{kT}}+e^{-\frac{\mu H}{kT}}}=\tanh x\,;\ \text{where } x=\frac{\mu H}{kT}$$

for small values of x, $\frac{\overline{m}}{\mu}=\frac{\mu H}{kT}$; an expresssion of Curie's law.

In the case of a crystalline powder we have to integrate for all values of θ between 0° and π°, and the corresponding expression is given by Ehrenfest

$$\frac{\overline{m}}{\mu}=E(x)=\frac{\chi}{3}-\frac{\chi^3}{15}+\ldots \text{for small values of } x$$

the same as Langevin's formula.

On the other hand if according to the quantum theory we assume that in the crystalline powder the magnetic axes of the particles can take up only n orientations with respect to the external field, which are multiples of the fraction $\frac{1}{n}$, we find that

$$\frac{m}{\mu}=L_n(x)=\frac{2n+1}{2n}\coth\frac{2n+1}{2n}x-\frac{1}{2n}\coth\frac{x}{2n}\,;\ x=\frac{\mu H}{kT}$$

in the limit $n=\infty$, the formula passes to Langevin's form. Debye has tested the formulas of Langevin, Lenz and Ehrenfest which represents the variation in $\frac{\overline{m}}{\mu}$ of a paramagnetic substance with x. For $Gd_2(SO_4)_3,\ 8H_2O$, $\frac{\overline{m}}{\mu}$ reaches 80% of saturation value. Debye finds Lenz's formula and Ehrenfest's formula to be totally incapable of representing the experimental facts. while Langevin's formula and the above formula $L_n(x)$ for $n>3$ can be made to represent them. We have one word to say in conclusion about the mechanism by which the magnetic axis of a particle can suddenly turn through 180°. Lenz does not offer any picture, while Ehrenfest supposes that the electron in its orbits can suddenly reverse its direction of motion. Such reversal of orbital motion is difficult to account for. But if we consider the paramagnetic phenomena to be due to the spinning electrons, then the reversal of the magnetic axis can be attributed to the reversal of the spin axis. We thus come to the conclusion that at present there is

no theory which is both theoretically satisfactory and also well represents experimental facts.

Weiss's and Bohr's Magnetons and their relation to atomic structure.

If we look back upon the formula deduced by Langevin we find that

$$X_M T = \frac{M_0^2}{3R} = C, \text{ Curie's constant}$$

$$= \frac{M_0^2}{R}\overline{\cos^2\theta}$$

the more general formula.

This gives us a method of determining the magnetic moment of a paramagnetic compound

$$M_0 = \sqrt{3RC} = \sqrt{\frac{RC}{\cos^2\theta}}.$$

Wiedemann had discovered that in a paramagnetic salt it is the cation to which almost entirely the magnetic moment of the molecule is due. With the help of Wiedemann's law it is possible to determine the magnetic moment of a gm. atom of a paramagnetic ion. To Weiss belongs the credit of the discovery that the magnetic moment per gm. atom of these ions, and also of iron and nickel in a state of complete saturation at the absolute zero of temperature or at temperatures above the Curie point can be represented as small multiples of a unit which

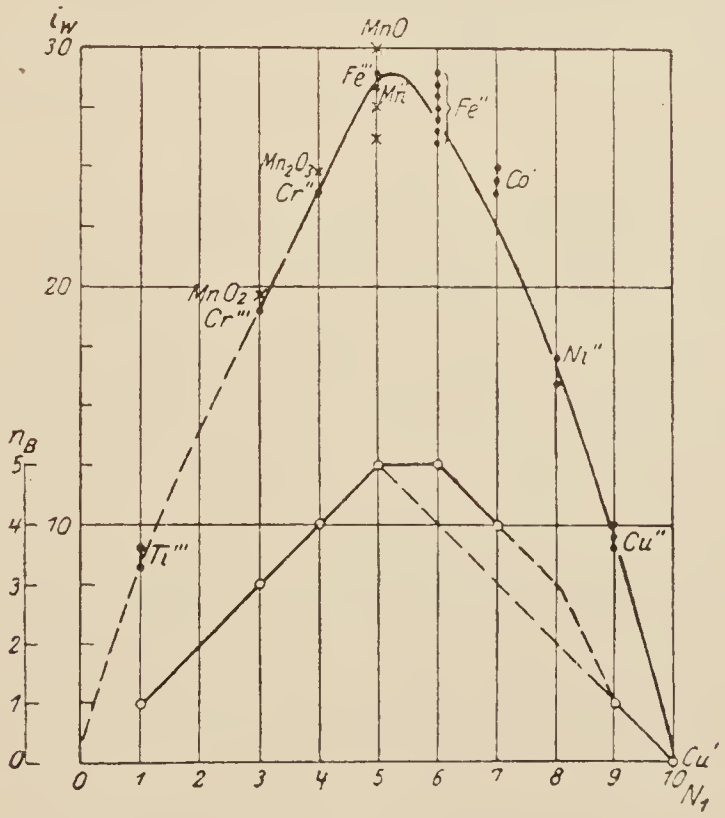


FIG. 8.

is equal to 1123·5 Gauss cm. and is known as Weiss's magneton M_w

$$ie\ .\ M_0 = n_w\ .\ M_w = n_w \times 1123{\cdot}5.$$

In the accompanying figure 8 the number of Weiss's magnetons contained in the ions of the elements of the first transition period is represented as a function of the number of electrons contained in it. It will be seen that certain di- and trivalent ions which possess the same number of electrons have also the same number of Weiss's magnetons. This has given rise to what is known as Kossels magnetic displacement law, which states that the magnetic moment depends not on the central charge but on the number and distribution of electrons in the different orbits. Even higher magneton numbers are met with when we consider the trivalent ions of the elements of the rare earth group (fig. 9).

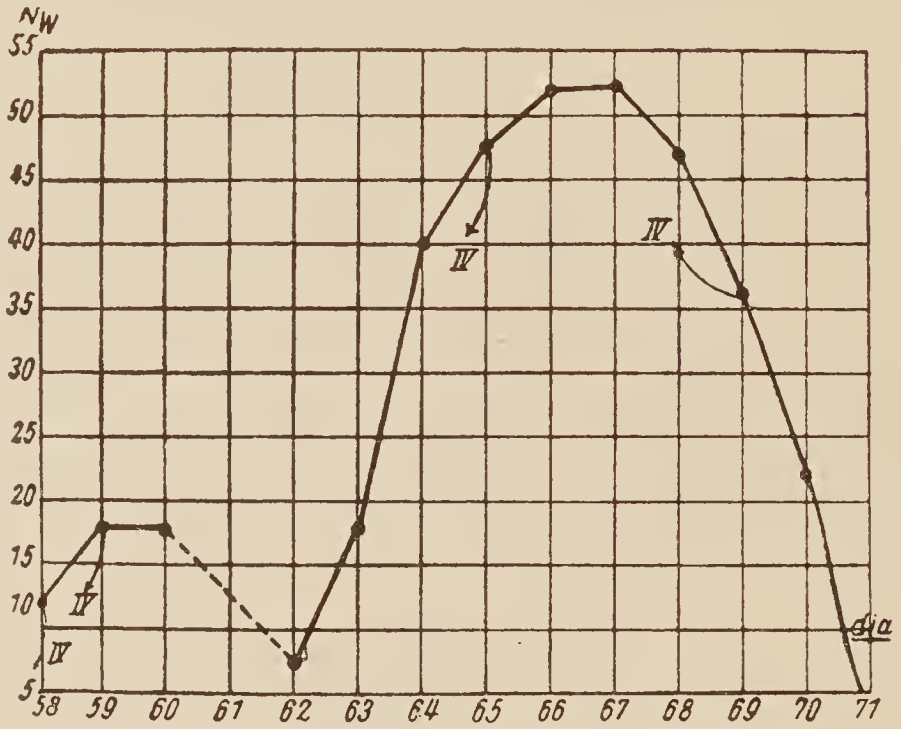


Fig. 9.

It seems that in the transition group of elements we meet with high magnetic susceptibilities. There are two other such groups viz. the Rhodium, and the Platinum group of elements. Not much investigation has been made with these elements.

Relation to Bohr's Magneton.—Recently through the development of Quantum Theory, a new unit of magnetic moment has been introduced viz. Bohr's Magneton. According to Bohr in an atom the electrons round a positive nucleus move in certain discrete orbits which are characterised by the angular moment p of the electron being a multiple of a certian unit $\frac{h}{2\pi}$, where h is Planck's quantum of action, *i.e.* we can write $p = k\frac{h}{2\pi}$. On the other hand we have the relation

$$\mu = \frac{e}{2mc} p = \frac{eh}{4\pi mc} \cdot k$$

where k is known as the azimuthal quantum number of the electron orbit. For

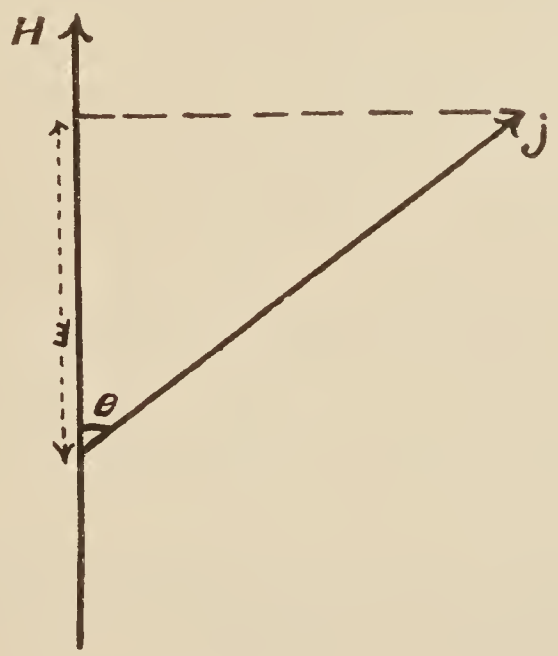
$$k=1\ ;\ \mu=\mu_1=\frac{eh}{4\pi mc}$$

is known as Bohr's magneton. The magnetic moment per gm. atom of an element each of whose atom contains one Bohr's Magneton is given by

$$M_B = N \cdot \mu_1 = 5584 \text{ Gauss cm}\ ;$$

which is equal to 4·97 times Weiss's Magneton. In an atom which contains several electrons, the resulting angular moment of the atom as a whole is represented by $j \cdot \frac{h}{2\pi}$; where j is known as the inner quantum number, and the corresponding magnetic moment of the atom is given by $\mu = j \cdot \mu_1$.

We shall now consider what experimental evidence there is for the existence of Bohr's Magneton. Before doing that we



shall discuss the theoretical considerations on which all these measurements are based. The first is the theory of spatial quantisation. An atom whose resultant moment is zero is characterised by $j=0$; such an atom will not take up any special position with respect to an external magnetic field. For all other values of j an atom will take up a discrete number of positions with respect to an external field equal to $2j+1$.

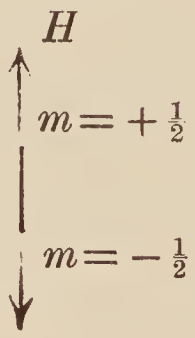
Thus if we call the resolved part of j parallel to H as the magnetic quantum number m

then we have

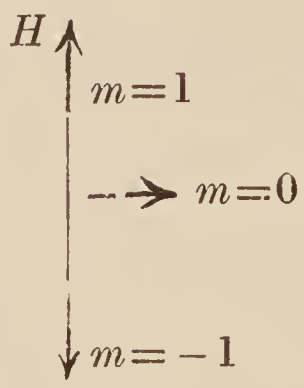
$$\cos\theta=\cos j\hat{H}=\cos\mu\hat{H}=\frac{m}{j} \text{ where } |m| \leq j.$$

We shall give the various possible values of m, corresponding to each value of j.

(*i*) $j=\frac{1}{2}$; $m=\pm\frac{1}{2}$



(*ii*) $j=1$; $m=\pm 1, 0$



and so on.

The magnetic energy of such an atom is

$$dW=\mu H\cos(\mu H)=\mu H\,.\,\frac{m}{j}$$

if μ represents the magnetic moment of the atom in terms of Bohr's unit, then μ is a simple number and is according to the theory of simple Zeeman effect $=j$;

then $$dW=\frac{\mu}{j}H\,.\,m=H\,.\,m.$$

But it is found that in general in those cases where the spectron of an atom shows anomalous Zeeman effect

$$\frac{\mu}{j}\neq 1, \text{ but} = g\,;$$

where g is known as anomalous Zeeman effect factor. It has an intimate relation with the magneto-mechanical anomaly we have discussed before. Therefore $\mu = jg$; according to Sommerfeld

$$g = \tfrac{3}{2} + \tfrac{1}{2}\frac{(j_s - j_a)(j_s + j_a + 1)}{j(j+1)};$$

by analysis of the Zeeman effect of spectral terms, it is possible to find both the values of j and g corresponding to any state of excitation of an atom. If these values are found out when the atom is in its normal state then the magneton number of atom in its normal state can be determined.

Experimental proof of directional quantisation of atoms in a magnetic field :—Stern and Gerlach's [1] experiments.

If a stream of atoms with magnetic moments μ are sent across an inhomogeneous magnetic field, then the force acting on each atom $= \mu$ grad H . cos μH.

According to the classical theory $\mu\hat{H}$ can have all possible values between 0 and π. In that case a narrow strip of the atomic rays is spread out into a broad band by action of the inhomogeneous field. On the other hand if the theory of directional quantisation is true, the original narrow band is split up into a number of discrete bands equal to $2j+1$. Thus if $j = \frac{1}{2}$ then $\cos \mu\hat{H}$, can either be ± 1. and the magnetic axis of the atoms are either parallel or antiparallel to the direction of the magnetic field.

Stern and Gerlach first experimented with a stream of vapourised silver atoms and found the following picture: the deposit on a glass plate was separated into two discrete bands with no undeflected band in the middle ; knowing the gradient of the magnetic field and the length of the path of the silver stream in it, and the average value of the velocity of the silver atoms, these investigators found that $\mu_{Ag} = 1$ Bohr's Magneton within 5%. Subsequent investigations have shown that *Cu*, *Ag*, *Au* all possess 1 Bohr's magneton which makes $g = \frac{\mu}{j} = 2$ in agreement with spectroscopic data. There is no deflection in the case of *Zn*, *Ca*, *Hg*, *Pb* which corresponds to $j = 0$; again in accordance with spectroscopic data. The case of $\mu = 0$ for *Fe* is not in accordance with spectroscopic evidence. In the case of nickel, Gerlach found three strips, one undeflected and the other two deflected in opposite directions ; this would correspond to $j = 1$; $\mu = 2$; which is again difficult to interpret spectroscopically.

Thus from these experiments, we have direct proof of space quantisation of magnetic atoms, and the physical existence

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[1] Gerlach and Stern—Ann. d. Phys. 74, 673, 1924.

of Bohr's Magneton. As it is difficult to conceive the existence of two different kinds of Magneton—the Weiss's and Bohr's, it is necessary to see if the atomic magnetic moments of ions can also be represented in terms of Bohr's magneton. We have found before that the Curie's constant

$$C=\frac{M_0^2}{R}\,\overline{\cos^2\theta}\,;$$

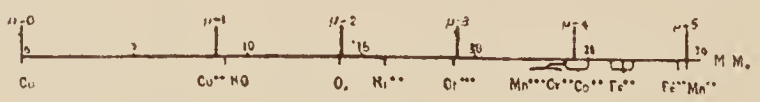
according to Langevin's theory the value of $\overline{\cos^2\theta}=\frac{1}{3}$, and then we find that we can express M_0 as a multiple of Weiss's Magneton $M_0=n_W.M_W$. On the other hand according to quantum theory $\cos\theta=\frac{m}{j}$ and according to different values of j the value of $\overline{\cos^2\theta}$ is different. Thus

$$C=\frac{(n_W M_W)^2}{3R}=\frac{(n_B M_B)^2}{R}\,\overline{\cos^2\theta}$$

where n_B no. of Bohr's magnetons M_B contained in the given substance; from which it follows

$$n_W=n_B\cdot\frac{M_B}{M_W}\cdot\sqrt{3\,\overline{\cos^2\theta}}=n_B\,.\,4{\cdot}97\sqrt{3\,\overline{\cos^2\theta}}.$$

In the following table (fig. 10) is given the different values of n_W which correspond to different values of j and



Tab. 67.

j	$\overline{\cos^2\vartheta}$	$\sqrt{3\,\overline{\cos^2\vartheta}}$	M/M_{II}
$\frac{1}{2}$	$\frac{1^2+(-1)^2}{2}=1$	$\sqrt{3}=1.73$	8.6
1	$\frac{1^2+0+(-1)^2}{3}=\frac{2}{3}$	$\sqrt{2}=1.41$	14.1
$\frac{3}{2}$	$\frac{1^2+(\frac{1}{2})^2+(-\frac{1}{3})^2+(-1)^2}{4}=\frac{5}{9}$	$\sqrt{\frac{5}{3}}=1.29$	19.2
2	$\frac{1^2+(\frac{1}{2})^2+0+(-\frac{1}{2})^2+(-1)^2}{5}=\frac{1}{2}$	$\sqrt{\frac{3}{2}}=1.22$	24.4
$\frac{5}{2}$	$\frac{1^2+(\frac{3}{5})^2+(\frac{1}{5})^2+(-\frac{1}{5})^2+(-\frac{3}{5})^2+(-1)^2}{6}=\frac{7}{15}$	$\sqrt{\frac{7}{5}}=1.18$	29.4

FIG. 10.

consequently of n_B. In the diagram at the top of the table, is plotted the values of n_W corresponding to different values of Bohr's magneton. Along with it are plotted the number of Weiss's magnetons contained in ions like T_i^{+++}, C_u^{++}, F_e^{++}, F_e^{+++} etc. It cannot be a mere accident that the Weiss's magnetons corresponding to these ions are concentrated at places which correspond to integral values of Bohr's magneton. I believe that in places where there is considerable deviation, it will be shown by later experiments that Weiss's temperature correction Δ has not been taken into account *e.g.* it is found for certain simple salts of nickel, and certain sixfold ammonia compounds the value of $n_W=16$ as opposed to the nearest Bohr's value of $n_B=^2$, $n_W=^{14\cdot1}$. We have in this laboratory tested the six-fold and four-fold hydrazine compounds of nickel prepared by Mr. Priyadaranjan Ray and found that n_W varies from 13·5 to 14·8 which is very close to the theoretically expected value. There is thus reasonable ground for supposing that the Bohr's magneton can also be used for representing the number of magnetons contained in paramagnetic ions.

Relation between the magneton number of atoms and ions and their corresponding electronic structure.

Bohr[1] in a very important paper published in 1923, has given a picture of the formation of atoms through the successive

Tabelle 1. Elektronenbahntypen der Elemente.

N \ n_k	1_1	2_1 2_2	3_1 3_3 3_3	4_1 4_2 4_3 4_4	5_1 5_2 5_3 5_4 5_5	6_1 6_2 6_3 6_4 6_5 6_6
1 H	1					
2 He	2					
3 Li	2	1				
4 Be	2	2				
5 B	2	2 (1)				
— —	—	— —				
10 Ne	2	4 4				
11 Na	2	4 4	1			
12 Mg	2	4 4	2			
13 Al	2	4 4	2 1			
— —	—	— —	— —			
18 A	2	4 4	4 4			
19 K	2	4 4	4 4	1		
20 Ca	2	4 4	4 4	2		
21 Sc	2	4 4	4 4 1	(2)		
22 Ti	2	4 4	4 4 2	(2)		
— —	—	— —	— — —	—		
29 Cu	2	4 4	6 6 6	1		
30 Zn	2	4 4	6 6 6	2		
31 Ga	2	4 4	6 6 6	2 1		
— —	—	— —	— — —	— —		
36 Kr	2	4 4	6 6 6	4 4		
37 Rb	2	4 4	6 6 6	4 4	1	
38 Sr	2	4 4	6 6 6	4 4	2	
39 Y	2	4 4	6 6 6	4 4 1	(2)	
40 Zr	2	4 4	6 6 6	4 4 2	(2)	
— —	—	— —	— — —	— — —	—	
47 Ag	2	4 4	6 6 6	6 6 6	1	

FIG. 11.

[1] Bohr—"The Theory of Spectra and Atomic Constitution."

capture of electrons by the atomic nucleus. Each electron moves round the nucleus in a definite orbit characterised by the two quantum numbers n and k; corresponding to each value of n, $k=1, 2 \ldots n$. These bound electrons are arranged in shells characterised by different values of n e.g. for $n=1$ we have the k shell, $n=2$ the L shell, $n=3$ the M shell, and so on. In each completed shell there are $2n^2$ electrons thus the K shell is completed in H_e with 2 electrons, the L shell is completed in N_e with 8 electrons, in Argon the M shell is partially completed with 8 electrons, while in Krypton the M shell has received its full complement of $2 \cdot 3^2 = 18$ electrons.

Between Argon and Krypton occur the first transition

TABLE II —Suggested Distribution of Electrons.

The distribution of electrons in the atoms is given by the part of the table above and to the left of the thick lines]

Element.	Atomic Number.	Level (n).	Sub-Level. (k, j.)						
			I	II	III	IV	V	VI	VII
			1, 1	2, 1	2, 2	3, 2	3, 3	4, 3	4, 4
He	2	K (1)	2						
Ne	10	L (2)	2	2	4				
A	18	M (3)	2	2	4	(4	6)		
Kr	36	N (4)	2	2	4	(4	6)	6	8
Xe	54	O (5)	2	2	4	(4	6)		
Nt	86	P (6)	2	2	4				

FIG. 12.

group of elements beginning with *Sc* (21) and ending with *Cu* (29). In these elements according to Bohr, the M-shell which was subdivided into two subgroups of 4 electrons is now formed by 3 subgroups containing 6 electrons each. Bohr has pointed out that in the places where an inner shell is in the process of completion the atoms and their compounds show strong paramagnetic susceptibility, colour, catalytic activity, etc. Other places in the periodic table where such completion of an inner shell takes place are in the Rhodium, the Platinium, and the rare earth group of elements. Bohr has been able to marshal a large number of optical, X-ray, and other data in support of his classification. But there are certain groups of facts which do not fall in with Bohr's scheme. Stoner[1] in

[1] Stoner, Phil. Mag. 48, 719, 1924.

1924 gave a more detailed and improved picture of the successive formation of electronic shells. He has shown (see fig. 12) that the orbit of each electron is characterised by three quantum numbers nkj where j is equal to k or $k-1$; therefore each of Bohr's sublevel n_k is divided into two more, except in the K shell where $k=1$. Stoner assumes that in each sublevel the number of electrons $=2j$. In this way Stoner has succeeded in giving a better picture of the phenomena of X-ray absorption, spectral terms, etc. Even a large number of chemical facts fit better with Stoner's classification as has recently been shown by Sommerfeld and Grimm.

According to Stoner in the first transition group of elements the $M_{32}+M_{33}$ sublevels are completed with $4+6$ electrons ; and in the rare earth group the $N_{43}+N_{44}$ sublevels are completed with $6+8$ electrons. We shall show here that these are certain magnetic evidences which point to the successive formation of the two Stoner's sublevels. In the rare earth group the elements are either tri- or tetravalent. If we examine the curve giving the magneton number of these ions as function of electron number, we see that the curve (see fig 9) is divided into two groups corresponding roughly to the Cerium and Ytterbium group of elements. It appears that the N_{43} subgroup is nearly completed before the N_{44} subgroup. This fact was first pointed out by Sommerfeld, who was of opinion that no corresponding magnetic evidence exists which can point to the successive formation of the $M_{32}+M_{33}$ subgroups in the first transition group of elements.

In a recent paper [1] I have been able to show that from magnetic evidence it can be concluded that the M_{33} subgroup is completed between $Sc(21)$ and $Fe(26)$, while the M_{32} is completed between $Co(27)$ and $Cu(29)$. If we examine the Bohr's Magneton curve for this group, we find that it consists of straight lines equally inclined to the horizontal axes and which intersect at $Fe^{+++}Mn^{++}$. We find that in the first portion of the curve Kossel's magnetic displacement law holds good. While in the second portion Co^{++} is outside the curve. The value of Co^{+++} is not plotted, as its simple salts are very unstable. Weber has measured the number of Weiss's magnetons contained in solution of $Co_2(SO_4)_3$ and found it to be less than 17, which corresponds to 2·5 Bohr's magnetons. Now Fe^{++} and Co^{+++} have the same electron numbers but their magneton numbers are widely separate. This leads one to suspect that in Cobalt a new subgroup is being formed. The number of elements between $Sc(21)+Fe(26)$ is 6, from which it is concluded that the M_{33} subgroup with 6 electrons is completed at $Fe(26)$. I have further tried to calculate the number of magnetons μ contained in the atoms and ions of

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[1] Bose, Zeit.f.Phys. 35, 213, 1925.

these elements, from the distribution of electrons in the M_{32}, M_{33} and N_{11} subgroups. Having given the distribution it is found that $\mu = m_{33} + n_{11} - m_{32}$ where these numbers represent the number of electrons in the corresponding sublevel. The assumptions underlying the above formula are

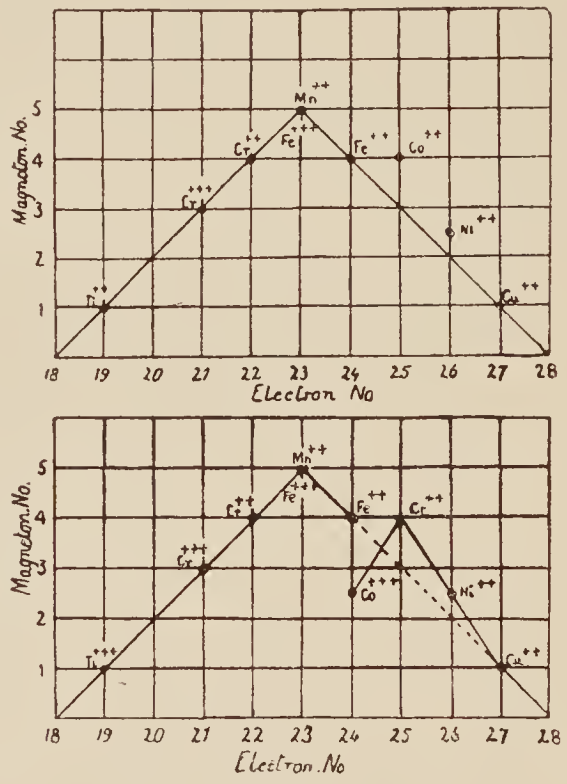
Magneton No.
Electron No
18 19 20 21 22 23 24 25 26 27 28
1 2 3 4 5
Ti+++ Cr+++ Mn++ Fe+++ Fe++ Co++ Ni++ Cu++
Magneton No.
Electron No.
Ti+++ Cr+++ Cr++ Mn++ Fe+++ Fe++ Co+++ Cr++ Ni++ Cu++

FIG. 13.

(*i*) that each electron in the M_{33} and N_{11} sublevel contributes 1 unit to the magneton number, while each electron in the M_{32} subgroup contributes -1 unit.

(*ii*) when each sublevel has received the maximum number of electrons it can contain, its resulting magnetic moment is zero.

ATOM OR ION	NO OF ELECTRONS	NO. OF ELECTRONS IN ORBITS				BOHR'S MAGNETON NUMBER			
		M_{32}	M_{33}	N_{11}	$M_{33}+N_{11}+M_{32}$	ATOMIC	IONIC	SPECTROS	
Ti	22	-	2	2					2+2-0-2
Ti^{+++}		-	-	1	1+0+0=1		1		
Va	23	-	3	2					5+2-0=3
Cr	24	-	5	1				6	5+1-0=6
Cr^{+++}	21	-	3	-	5+0+0=5		3		
Cr^{++}	22	-	3	1	3+1-0=4		4		
Mn	25	-	5	2				5	5+2-0=5
Mn^{++}	23	-	4	1	4+1-0=5		5		
Fe	26	-	6	2	6+2-0=0	0		6	6+2-0=6
Fe^{+++}	23	-	4	1	4+1-0=5		5		
Fe^{++}	24	-	4	2	4+2-0=4		4		
Co	27	1	6	2	6+2-1=1			6	6+2-1=5
Co^{+++}	24	2	4	-	4+0-2=2		2·5		
Co^{++}	25	2	4	1	4+1-2=3		4		
Ni	28	2	6	2	6+2-2=2	2		5	6+2-2=4
Ni^{++}	26	2	6	-	6+0-2=2		2·5		
Cu	29	4	6	1	6+1-4=1	1			
Cu^{++}	27	2	6	1	6+1-2=1		1		

FIG. 14.

In the accompanying table, (fig. 14.) I have made the calculation and compared with the experimentally determined magneton numbers of paramagnetic ions and also of the atoms of *Fe Co, Cu.* It is interesting to note that according to the distribution proposed by me the magnetic moment of *Fe* atom does come out to be zero.

An interesting confirmation of this proposed distribution comes from the recent measurement of the separation of the K_a doublets in the lighter elements by Siegbahn and Ray. According to Sommerfeld's theory the separation

$$\Delta\nu_{k\alpha} = R(Z-3{\cdot}5)^4\frac{\alpha^2}{24}\left\{1+\frac{5}{2}\frac{\alpha^2}{23}(Z-3{\cdot}5)^2+..\right\}.$$

For the heavier elements there is substantial agreement between the theoretical and experimental values of $'\Delta\nu_{k\alpha}$. But for the lighter elements the authors found a systematic deviation from the theoretical value, and the separation is maximum in Iron. (See fig. 15.) This led me to suspect that this deviation from the theoretical value is of magnetic origin. I have in a recent paper[1] shown that

$$\frac{\Delta\nu}{R}=\frac{\Delta\nu_{rel}}{R}+\frac{\Delta\nu_{mag}}{R}\text{, and }\frac{\Delta\nu_{mag}}{R(z-3{\cdot}5)^3}=\frac{\alpha^2}{14}\text{ or }\frac{3\alpha^2}{3^2}$$

according to the different assumption one makes.

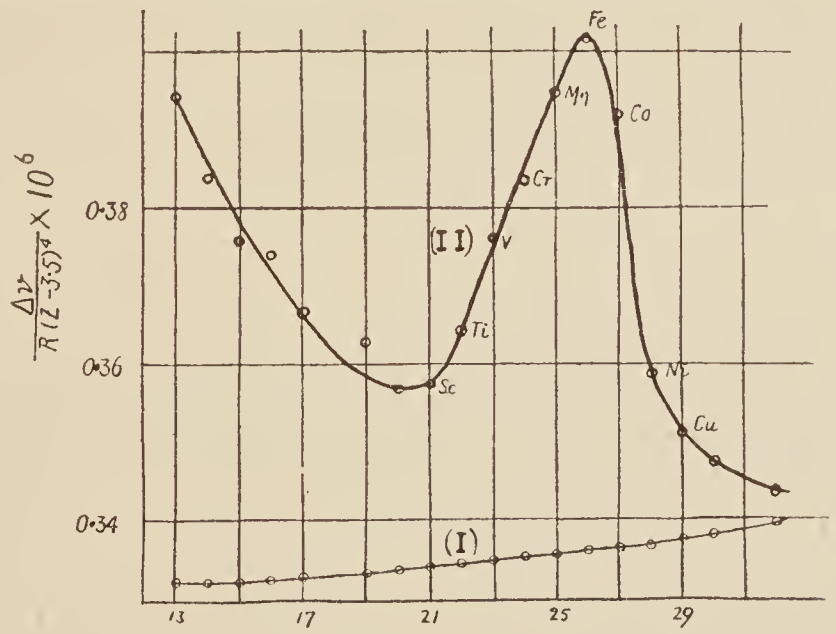

FIG. 15.

For the first portion of the curve there is a substantial agreement between the theoretically and experimentally found values of $\frac{\Delta\nu_{mag}}{R}$. The subsequent rise of the curve begins at

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[1] Bose, Phys. Rev. 27, 521, 1926.

Sc (21) and has a maximum at *Fe* (26) and then falls to a minimum at about *Cu*(29). This can be explained on the assumption that the 6 electrons in the M_{33} shell all move in the same sense, and the magnetic moment due to them is neutralised by the magnetic moment of the electrons in the M_{32} shell which move in the opposite direction.

Spectroscopic method of determining Magneton number of an ion or atom.

I shall now give an account of the method used by Hund [1] to calculate the value of μ of the atoms and ions of paramagnetic elements purely from spectroscopic considerations. By an extension of the method given by Heissenberg, Hund has succeeded in calculating purely from the distribution of

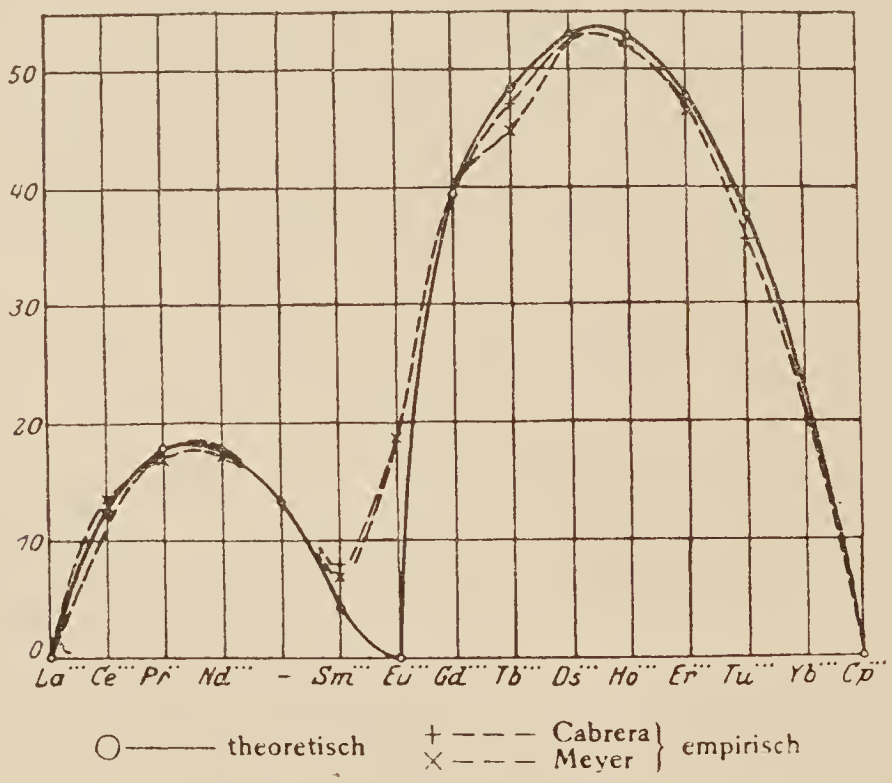

FIG. 16.

electrons in any shell and from their quantum numbers the fundamental spectral term of an atom when either neutral or ionised. He has done this with the help of certain assumptions into which it is not necessary to enter here. Knowing the fundamental term it is possible to calculate both the values of j and g corresponding to it and from that $\mu = j.g$. The spectra of the rare earth elements have not yet been studied, but with the help of this method Hund has succeeded in calculating the fundamental spectral terms of the trivalent ions of these elements, and from that the values of $\mu = g.j$ as expressed in terms of Bohr's magneton. In the accompanying curve (see fig. 16) are given the Weiss's magneton numbers of these trebly ionised atoms as functions of their electron numbers. It will be

[1] Hund, Zeit.f.Phys. 33, 855, 1925.

seen that except for Eu^{+++} the agreement is remarkably good. But when this method was applied by Hund to the calculation of the magnetic number of ions of the iron group, there was total discrepancy with the experimental values (see fig. 17). It is difficult to explain the reason why in one group of elements the agreement is almost perfect and in the other totally wanting.

Magneton number in complex compounds of the 1st transition group of elements.

So far we have been studying the number of magnetons contained in the simple compounds of paramegnetic elements. There is another class of compounds of these elements—the so-called co-ordination or complex compounds of Werner, whose magnetic properties present certain interesting anomalies. Thus while certain complex compounds of Fe^{++}, Co^{+++} are diamagnetic, other compounds of $Fe^{+++}Cu^{++}Ni^{++}Cr^{+++}$ are paramagne-

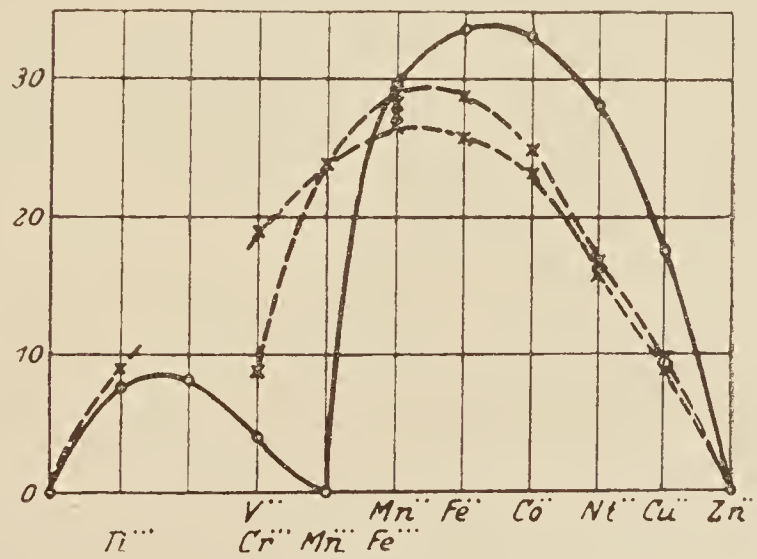

FIG. 17.

tic. In the second class the magneton numbers of both the simple and complex compounds of $Cr^{+++}Cu^{++}Ni^{++}$ are the same, while in the case of Fe^{+++} it is different. In a recent paper [1] I have offered an explanation of these anomalies.

If we take a typical co-ordination compound as

$$K_4Fe(CN)_6,\ 3H_20$$

it can also be written as $Fe(CN)_2+4KCN,\ 3H_20$ where the iron is divalent, and we have an association of two different types of molecule in the given compound. In the case of $K_3Fe(CN)_6$ we can write it as $Fe(CN)_3+3KCN$, and the iron is trivalent. Werner writes these compounds in the following forms

$$[Fe(CN)_6]K_4+3H_2O,\ [Fe(CN)_6]K_3$$

[1] Bose. Zeit.,f.Phys. 35, 219, 1925.

and supposes that the nature of bonding between the co-ordinating atoms and the group or elements inside the bracket is quite different from that with the groups or elements outside the bracket. The first group Werner supposes to be attached to the primary sphere of influence of the co-ordinating atom, and the second group to the secondary sphere. The number of bonds in the former is known as the co-ordination number of the compound. Recent X-ray analysis of the crystals of some of these co-ordination compounds has given a large measure of physical support to Werner's speculations. For these class of compounds Sidgwick has calculated what he calls the " effective atomic number " of the co-ordinating atom, which he defines as the number of electrons contained in it together with the number which the latter shares with the atoms and groups which are associated with it. He has given a rule for calculating it, but I find the following formula to be simpler. If Z^1 is the effective atomic number then $Z^1 = A - P + 2\,C$ where A is the atomic number of the co-ordinating atom, P its primary valency in the given compound, and C the number of co-ordination bonds and is 4, 6, etc., according as the compound is fourfold or sixfold, etc. Applying this to the case of the two compounds mentioned above we have for

$$K_4Fe(CN)_6 \qquad Z^1 = 26 - 2 + 6 \times 2 = 36.$$

$$K_3Fe(CN)_6 \qquad Z^1 = 26 - 3 + 6 \times 2 = 35.$$

In the first case $Z^1 =$ the number of electrons contained in $Kr(36)$, the inert gas which terminates the first long period. Sidgwick thought that he saw in this the tendency of the outer shell of the co-ordinating atom to have the configuration of 18 electrons, just as in simple compounds there is a tendency to the formation of the 8-electron configuration. But there are a large number of complex compounds in which the configuration of 18 is not satisfied, e.g. in

$$[Cr(NH_2)_6]I_3 \; Z^1 = 24 - 3 + 6 \times 2 = 33.$$

I have found [1] that in all complex compounds the number of Bohr's magnetons contained is $n_B = Z - Z^1$ where Z is the atomic number of the inert gas which completes the transition of group of elements to which the co-ordinating atom belongs. This means that when the co-ordinating atom takes the configuration of the inert gas next to it, it becomes diamagnetic as the latter, otherwise it is paramagnetic by an amount which is equal to the number of electrons necessary to bring it to the inert gas configuration. The acompanying table (see fig. 18) shows that there is good agreement between the theoretical and experimental values. The test of a theory is not only that

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[1] Bose, Zeit.f.Phys. 35, 219, 1925.

it succeeds in explaining known facts, but when it succeeds in predicting the behaviour of new types of compounds. Recently in the Chemical Laboratory of the University College of Science, Mr. P. R. Ray has succeeded in preparing some new type of fourfold co-ordination compound of divalent cobalt viz. $[Co(N_2H_4)_2]SO_3$

Elements	Atomic No	Complex Compounds	Effective atomic No Z^1	No. of Bohr's Magnetons	
				Calc. $Z-Z^1$	Exp. Found
Cr (Chromic)	24	$[Cr(NH_3)_6]I_3$	$6\times2-3=9+24=33$	$36-33=3$	3
		$Cr\begin{bmatrix}(NH_3)_4\\(Cl_2)\end{bmatrix}I$	$4\times2+2-1=9+24=33$	$36-33=3$	3
Fe (ferrous)	26	$[Fe(CN_6)]K_4$	$6\times1+4=10+26=36$	$36-36=0$	Diamagnetic
		$\left[Fe\begin{matrix}(CN)_5\\(NH_3)\end{matrix}\right]Na_3$	$5\times1+2+3=10+26=36$	$36-36=0$	,,
(ferric)		$[Fe(CN)_6]K_3$	$6\times1+3=9+26=35$	$36-35=1$	1
		$\left[Fe\begin{matrix}(CN)_5\\H_2O\end{matrix}\right]Na_2$	$5\times1+2+2=9+26=35$	$36-35=1$	1
		$[Fe(CO)_5]$	$5\times2=10+26=36$	$36-36=0$	Diamagnetic
Co (Cobaltic)	27	$[Co(NH_3)_6]Cl_3$	$6\times2-3=9+27=36$	$36-36=0$	,,
		$\left[Co\begin{matrix}(NH_3)_3\\(NO_2)_2\\Cl\end{matrix}\right]$	$3\times2+2+1=9+27=36$	$36-36=0$	,,
Ni	28	$[Ni(CO)_4]$	$4\times2=8+28=36$	$36-36=0$	,,
		$[Ni(NH_3)_4]SO_4$	$4\times2-2=6+28=34$	$36-34=2$	2
		$[Ni(NH_3)_6]SO_4$	$6\times2-2=10+28=38$	$36-38=-2$	2·5
Cu	29	$[Cu(NH_3)_4](NO_3)_2$	$4\times2-2=6+29=35$	$36-35=1$	1

FIG. 18.

Its effective atomic number $Z^1=27-2+4\times2=33$ and the number of Bohr's magnetons is $Z-Z^1=36-33=3=19{\cdot}6$ Weiss's Magnetons. Preliminary magnetic measurements undertaken in our laboratory gives the Weiss's magneton number contained in the compound to be about 20, in very good agreement with the calculated value. The rule enunciated by me is now being applied by Mr. Ray in testing the valency in a number of co-ordination compounds he is preparing. The chemical test is very tedious while the magnetic test can be made within a few hours and is simple. I think that the ability to predict the number of Bohr's magnetons contained in the above formula is a strong experimental verification of the possibility of representing the magnetic moments of paramagnetic ions in terms of Bohr's magnetons.

Abstracts of Papers.

1. On a method of determining the ionisation potential of elements showing flame lines.

SNEHAMOY DATTA *and* SURESH CHANDRA SEN.

In the last meeting of the Science Congress it has been shown by one of the authors that if the atoms in the Bunsen flame, a considerable fraction of which are in the excited state having an energy $v_r.e$ are bombarded by thermions accelerated by an electric field, then kinks are obtained in the current potential curve at voltages $v_i - v_r$, where v_r is the resonance and v_i the ionisation potential of the elements.

The method hitherto adopted was defective in as much as the curves showed a general increase in current due to rise in voltage plus the increase due to ionisation, so that the ionisation current could not be studied separately; and as the curves were nearly parabolic a small abrupt rise at any point could neither be detected with certainty nor distinguished from the inevitable errors in observation arising out of the fluctuations in the ordinary Bunsen flame.

In the present case the ordinary Bunsen burner has been substituted by a modified one used by Bancroft and Weiser, which could be regulated at will and could be maintained steady as long as it was desired. The fluctuations in the flame were thus considerably minimised and three sets of the conductivity readings of the flame were taken: (1) with Thorium only—Th. providing the thermions, (2) with Th. and the metallic salts, (3) with salts only. The excess of conductivity in (2) over the sum of (1) and (3) gave the actual increase due to ionisation alone. On plotting these against the voltage accelerating the thermions, the first portion of the curve was nearly parallel to the voltage axis so that the first kink due to ionisation could be definitely located.

The validity of the method has been proved by finding the I.P. of Na., K, and Hg. the results agreeing well with those previously determined by Franck. The method has also been extended to finding the I.P. of Li., Mg., Ca., Sr. and Ba. for which no previous determination is on record. The results show good agreement with that obtained from the spectroscopic series limit.

The shape of the curves and the non-existence of kinks at $V_i - V_r$, have also been discussed.

2. On the reversal of bands.

SNEHAMOY DATTA.

The phenomenon of reversal is quite a familiar thing with lines appearing in the arc and sometimes in the spark spectra of elements. When an arc is liberally fed with metallic salts, usually the members of the principal series first come out as reversed line. They appear as a sharp dark line in the middle of the bright emission line.

The corresponding phenomenon has never been noticed in the band spectra of elements or compounds. For the first time the author has succeeded in producing the reversal of bands with Calcium Fluoride. But of the numerous bands attributed to CaF_2, only those appearing in the orange red show these reversals. It is difficult to explain their appearance according to the modern theories of Band Spectra.

3. Ionisation potentials and atomic sizes.

Susil Chandra Biswas, Lahore.

According to Sir J. J. Thomson, the relation between the radius and ionisation potential of any atom for quick ionisation can be expressed as

$$I.P. = a_n \frac{e^2}{r_n}$$

where e is the electronic charge, r_n the radius of the atom having n outer electrons, a_n a numerical constant whose value changes with the increase of outer electrons or more properly for different groups of Mendeleef's table. Eve (Nature, June 30, 1921) computed results for the product of I. P. and atomic diameter (Bragg's value) and also for $I.P. \times \sqrt[3]{\text{At. volume.}}$ which results are widely divergent from group to group. Saha, on the other hand, calculated the radius of a number of atoms on the assumption that $I.P. \times r = a$ constant which remains the same for all the elements.

The present results are computed as (i) the product of I. P. and cube root of compressibility. Excepting for the elements of Group I, the constants for different groups as well as for the members of the same group are found to be very nearly the same (about 11·0). For alkali metals due to their very small cohesive forces the results do not seem to be so concordant specially at the heavy end of the period. For Cu, Ag, Au and Mn constants appear to be too low owing probably to their very small compressibilities. Allowance being made for all these the results can be expressed as

$$I.P \propto \frac{1}{\sqrt[3]{\text{Compressibility}}}.$$

Cube root of compressibility must be of the same magnitude as that of an atom and thus the relation above shows that Ionisation Potential varies inversely as the atomic dimension.

(ii) Work done in compressing cells in unit volume may be shown to be $\beta\left(\frac{dV}{V}\right)^2$ where β stands for compressibility and V for atomic volume.

J. J. Thomson has on a further calculation shown that β varies inversely as cube root of V^4. Thus $\beta^{\frac{1}{4}} \propto V^{\frac{1}{3}}$. According to Hughes and Eve

$$I.P \propto \frac{1}{\sqrt[3]{\text{at. volume}}} \text{ thus } I\ P \times \sqrt[4]{\text{Compressibility}}$$

should be constant. These results have been verified. The results by I and II methods seem to run on parallel lines.

4. Contributions to atomic physics. Part II. Ionisation potential and periodic classification.

Susil Chandra Biswas, Lahore.

(*a*) Classification of Ionisation Potential of atoms.

Ionisation potentials of atoms are arranged in groups of (i) Helium family, (ii) Neon family, (iii) Argon family, (iv) Krypton family, (v) Xenon family, (vi) Radium emanation or Niton family. This mode of classification brings under the same head atoms and ions isosteric with one another, or mostly related in their physical properties. Curves showing the relation between Ionisation Potentials and atomic numbers represent two characteristic branches corresponding to electro-positive and electro-negative elements of the same family which differs in their numbers of electron shells.

(*b*) Periodic relationship.

A linear relationship is found to exist between the Ionisation Potentials of any two elements of rare gases belonging to any two branches and those of any two other elements of any sub-group of Mendeleef's table belonging to the same branches, e.g. ratios of I. P.

$$\left|\begin{array}{ll} \frac{A}{Ne}=\frac{F}{Cl}=\frac{O}{S} & \text{etc.} \\ \frac{Kr}{A}=\frac{Br}{Cl}=\frac{Se}{S} & \text{etc.} \\ \frac{Xe}{Kr}=\frac{I}{Br}=\frac{Te}{Se} & \text{etc.} \end{array}\right\}$$

This relation is not so very clear in electro-positive series. Calculated Ionisation potentials of F, Se, Te, Sb, are 16·7, 10·55, 9·55 and 10·35 respectively which are checked by Eve's calculation.

(*c*) Periodic law of ionisation potential.

A law of Ionisation potential is thus proposed "Excepting probably for electro-positive atoms, the ratio between the ionisation potentials of any two simple atoms belonging to the same vertical column in Mendeleef's table is the same as the ratio between the ionisation potentials of any other two simple atoms on the same horizontal lines of the table, provided that these atoms also belong to a common vertical columns."

Or as in the present scheme, " Excepting probably for electro-positive elements there is a strict proportionality between the ionisation potentials of any two simple atoms limited by any two branches or shells in the vertical columns as with those of any two others belonging to the same two branches provided they belong to the same horizontal row."

5. Thermal ionisation of elements.

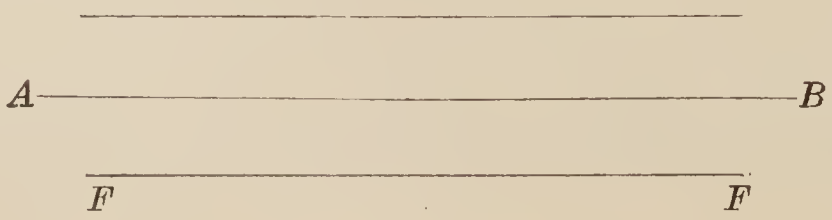
N. K. Sur *and* K. Majumdar, Allahabad.

(Communicated by Dr. Megnad Saha.)

The object of the experiments has been to verify experimentally the theory and equation of the thermal ionisation of elements as propounded by Saha. The experiment was conducted in the vacuum-furnace (as described in the Journal of the Indian Chemical Society, Vol. 1, No. 1, 1924) with some modifications and improvements.

The iron-sheet furnace in the form of a tube was replaced by an Acheson graphite tube as it could withstand the highest temperatures. This was heated by heavy electric current through water-cooled tubes and very thick leads as before; but the current was derived from a 10 Kilowatt Step-down transformer instead of direct from the battery, which quickly ran down owing to heavy draft of current. The temperature of the furnace could thus be kept constant for a long time.

8 An objection in the previous experiment by Saha and Sur was that the potential difference between the central wire AB and the tube furnace FF was not the



same throughout, for the two ends of the tube differed in potential by some 10 volts. Hence at least at one end of the furnace the p.d. between the wire and the furnace would be about 10 volts and this may in the case of some elements be greater than their ionisation potentials. This condition was got rid of by removing the central wire and employing two electrodes of Acheson graphite quite insulated from the furnace. This served not only to get rid of the above-mentioned objection but also served to make observations on only a short length of the furnace, where the temperature may be assumed to be perfectly constant.

Preliminary experiments carried out with alkali vapours prove qualitatively the correctness of Saha's theory of thermal ionisation.

6. On hot wire anemometry.

B. L. Gupta, Allahabad.

(Communicated by Dr. Megnad Saha.)

The fact that when a hot pt. wire is held across a stream of fluid, its temperature falls and its resistance decreases, has been employed in making what are known as hot wire anemometers by various workers including Morris, Thomas, and King. They all measured the change in the resistance by Kelvin's double bridge arrangement.

In the present paper attempt has been made to employ a thermionic valve in registering the wind velocity. In series with a pt. wire is placed the heating battery and fixed manganin wire resistance. Connections are taken from the two ends of the pt. wire, one to the grid of a thermionic valve and the other to the negative end of the filament heating battery. The steady anode current of the valve is balanced by an auxiliary battery The pt. wire is held diametrically inside a brass tube and insulated from it. When the stream of wind passes through the tube, the temperature and consequently the resistance of the wire changes. This brings about a change in the P.D. across the wire which is impressed upon the grid of the valve thereby causing a change in the anode current. It has been observed that the change in the anode current is constant for a given velocity.

Thus it is possible to make reliable anemometers by employing the above method. By introducing one or more amplifying valves the sensitiveness of the instrument can be increased enormously.

7. Some observations on electricity produced by dust storms.

B. L. Gupta, Allahabad.

(Communicated by Dr. Megnad Saha.)

It was found during April last year, that the transmitting antenna of the Physics Department of the Allahabad University used to be highly charged during dust storms. By putting a helium tube between the free end and the earth, flashes were observed every two or three seconds depending on the violence of the storm. As the helium tube did not flash below 2,500 volts, the voltage must have been 2,500 volts. The capacity of the antenna was measured by a Tinsley Bridge and found to be $\cdot 0004 \mu F$.

Experiments are in progress for measuring quantitatively the voltage and quantity of electricity produced in an artificial dust storm, and their variation with velocity of the storm. The charge on a mesh on which a blast laden with dust is directed, is measured by connecting it to the grid of a thermionic amplifier, and fluctuation in anode current is measured. Experiments are in progress.

8. On the spectrum of argon.

D. K. Bhattacharyya, Bankipore and Allahabad.

The above ideas (see abstract 13) have been applied to the explanation of the spectrum of Argon. The spectrum is apparently of much greater complexity than that of Neon, because Paschen and Meissner have discovered not less than $26P$ terms corresponding to the analogous terms in the case of Neon. There are also groups of lines which were discovered by Lyman and Dorgelo and Abbink in the Schumann region for which there is no analogy in the spectrum of Neon. A preliminary analysis shows that this is due to the possibility of more variety of transitions of the running electron amongst the Stoner levels. The possible combinations are

(A) $6M_2$ giving....$^1S_0$ discovered by Hertz.

(B) $5M_2$, M_3 giving combinations,

$$^1F \quad ^1\overline{D} \quad ^1P$$
$$^3F \quad ^3\overline{D} \quad ^3P.$$

(C) $5M_2$,N_1, giving the combinations,

$$^3P_{0,1,2} \qquad ^1P_1.$$

(D) $4M_2$, $2N_1$ giving the combinations,

$$^3\overline{P}, \quad ^1D_2 \quad ^1S_0.$$

(E) $5M_2$,N_2 giving the combinations,

$$^1S_0 \quad ^1P_1 \quad ^1D_2$$
$$^3S_1 \quad ^3\overline{P'} \quad ^3D_2.$$

(F) $4M_2N_1M_3$ giving the combinations.

$$^1F \quad ^1D \quad ^1P$$
$$^3F \quad ^3D \quad ^1P$$
$$^5F \quad ^3D \quad ^3P.$$

Combinations (D), (E), (F) will all give terms with (C) and 28 combinations with $^3P_1$ of (C) are possible; of this 26 have been obtained by Paschen and Meissner.

9. Note on the spectrum of nickel.

P. K. Kichlu, Allahabad.

(Communicated by Dr. Megnad Saha.)

The spectrum of Ni has been analysed by Bechert and Sommer, and they have shown that the fundamental terms discovered by them can be worked out on the basis of the following combinations :—

(A) $10M_3$ giving ....$^1S_0$, a case not treated by the above writers.

(B) $9M_3N_1$ giving the terms,

$$^3\overline{D} \quad ^1\overline{D}.$$

(C) $8M_3 2N_1$ giving terms,

$$^3F \quad ^3P \quad ^1\overline{S}_0 \quad ^1\overline{D}_2 \quad ^1\overline{G}_4.$$

(D) $8M_3$, N_1, N_2 giving the terms,

$$^5G \quad ^5\overline{F} \quad ^5D$$
$$^3G \quad ^3\overline{F} \quad ^3D$$
$$^1G \quad ^1\overline{F} \quad ^1D$$
$$^3G \quad ^3\overline{F} \quad ^3D.$$

The author has treated the following further combinations :—

(E) $9M_3$, $2N_2$ giving the terms,

$$^3F \quad ^3D \quad ^3P$$
$$^1F \quad ^1D \quad ^1P.$$

(F) $9M_3$, O_1 giving the terms,

$$^3\overline{D} \quad ^1\overline{D}.$$

(G) $8M_3$, N_1, O_1 giving the terms,

$$^3F \quad ^5F \quad ^3F \quad ^1F.$$

(H) $9M_3$, N_3 giving the terms,

$$^1\overline{S} \quad ^1P \quad ^1\overline{D} \quad ^1F \quad ^1\overline{G}$$
$$^3\overline{S} \quad ^3P \quad ^3\overline{D} \quad ^3F \quad ^3\overline{G}.$$

(I) $8M_3$, N_1, N_3 give

$$^5H \quad ^5\overline{G} \quad ^5F \quad ^5\overline{D} \quad ^5P$$
$$^3H \quad ^3\overline{G} \quad ^3F \quad ^3\overline{D} \quad ^3P$$
$$^1H \quad ^1\overline{G} \quad ^1F \quad ^1\overline{D} \quad ^1P.$$

The ^3F-term arising from (C) and one ^3F-term arising from (G) form a Rydberg sequence. Two sets of ^3F-terms arise in (G), of which the lower value has to be taken. But only one set has been discovered and as this is associated with ^5F, this cannot form the Rydberg sequence. We have approximately $1^3F-2^3F=50466$, and hence $1^3F=72495$ giving an approximate ionisation potential of 9 volts. Search is being made for higher terms of the Rydberg sequence which will enable the I.P. to be determined more accurately.

10. Series relation in the spectrum of copper.

P. K. Kichlu, Allahabad.

(Communicated by Dr. Megnad Saha.)

The spectrum of Cu has been studied both experimentally and theoretically. Photographs have been taken up to $\lambda 1940$ in the E_1, Hilger spectrograph using the different modes of excitation (ordinary heavy ampere arcs, vacuum arcs and sparks). Many groups of new lines have been discovered.

The author has discovered a new set of negative terms, which combines strongly with the quartet P, D, F terms. The spectrum has been discussed from the standpoint of the theories of complicated spectra from the following combination :—

(A) $10M_3$, N_1 which give the fundamental, $^3S_1$.

(B) $9M_3$, $2N_1$ give $^2D_{2,3}$.

(C) $9M_3$, N_1, N_2 which give us

$$^4F \quad ^4\bar{D} \quad ^4P$$
$$^2F \quad ^2\bar{D} \quad ^2P$$
$$^2F \quad ^2\bar{D} \quad ^2P.$$

Of these terms the first set of three has been discovered by Beals. The next two sets have been identified by the present writer with terms discovered independently by him, Shenstone and Beals, but designated by Beals as $b^4\bar{D}$ and $c^4\bar{D}$.

Terms:	16486	16428	16135	15709·8	18582	17345
	$^2P_1$	$^2P_2$	$^2\bar{D}_2$	$^2\bar{D}_3$	$^2F_3$	$^2F_4$

(D) $10M_3$, N_2 which give the regular doublets are identified by the present writer with the terms, $^2P_{1,\ 2}$.

(E) $8M_3$, $2N_1$, N_2.

These give us terms whose existence is rendered probable by the existence of corresponding terms in the spectrum of Ni. ($8M_3$, $2N_1$ give us the fundamental ^3F of the Ni and *mutatis mutandis* it is expected they will give corresponding terms for Cu+). They will give us the terms which will combine strongly with the D-terms of combination (B.) The actual existence of such terms is indicated by the large number of still unaccounted for terms of which a list has been published by the present writer in the Zeitschrift fur Physik. Detailed identification is proceeding.

(F) Combinations like $(9M_3)$, $(2N_2)$, $(9M_3)$ (N_1), (O_1), $(9M_3)$ (N_3) are considered. It is shown from energy considerations that the terms arising from $9M_3$, $2N_2$, may become negative.

The spectral behaviour of Cu indicates that two of its electrons can be simultaneously excited, and is thus in complete agreement with the behaviour of Cu terms.

11. On an interpretation of the spectrum of cobalt.

N. K. Sur, Allahabad.

(Communicated by Dr. Megnad Saha.)

The Pauli-Heisenberg theory of complicated spectra, and as extended by Hund and Saha, has been applied to the arc-spectrum of cobalt, of which a partial analysis has been given by Catalan and Bechert. There are nine electrons in the outer shells, which can be grouped into the following combinations :—

(a) $9M_3$ which give us ^2D.

(b) $8M_3$, $1N_1$ would give us

$$^4F \quad ^4P$$
$$^2F \quad ^2D.$$

(c) $7M_3$, $2N_1$ would give us

$$^4F,\ ^4P,\ ^2H,\ ^2\bar{G},\ ^2F,\ ^2D,\ ^2\bar{D},\ ^2P.$$

(d) $7M_3$, $1N_1$, $1N_2$ gives us

$$^2G \quad ^2\bar{F} \quad ^2D$$
$$^4G \quad ^4\bar{F} \quad ^4D$$

^6G $^6\bar{F}$ ^6D

^4G $^4\bar{F}$ ^4D

^4G $^4\bar{F}$ ^4D

^2G $^2\bar{F}$ ^2D

^2G $^2\bar{F}$ ^2D.

(*e*) $7M_3-1N_1-1O_1$ gives us

^6F ^4F ^2F

^6H ^6F ^6D

^4H ^4F ^4D

^2H ^2F ^2D.

Terms arising from combinations (*b*) and (*c*) have been identified with the normal levels discovered by Catalan. They range in value from 0 to —(6000), the two ^4F-terms having the largest value. Terms arising from (*d*) combine with terms (*b*) and (*c*), and they account for all the strongest terms. They range in value from 23611 to 432000.

The remaining terms are due to the combinations :—

(*f*) $7M_3,1N_1,1O_1$ which form higher Rydberg member to terms (*c*) $7M_3,2N_1$.

(*g*) $8M_3,O_1$ which form higher Rydberg member to (*b*) $7M_3,N_1,O_1$.

These terms have been identified and from these the ionisation potential of cobalt is calculated to be 8·51 volts.

12. On the Arc spectrum of bismuth.

G. R. Toshniwal, Allahabad.

(Communicated by Dr. Megnad Saha.)

The absorption spectrum of Bismuth up to temperatures of 1200°C. contains only three lines λ3067, 1954·5, 1959·9, and a number of bands. As the band spectrum persists up to temperatures of 1200°C., the more fundamental lines were traced by water-spark absorption experiments. By this method twenty lines were obtained in absorption. Attempts at series-classification pointed to the existence of more undiscovered lines in addition to those ordinarily measured. The investigation of the arc-spectrum of Bismuth with an arc of high current density (20 amperes) has definitely revealed the presence of more lines. The wave lengths of the lines have been measured and series relations are being investigated.

13. On the complete explanation of the spectra of the metals of the second group.

Meghnad Saha, Allahabad.

In this paper the theory of complicated spectra, worked out by Pauli, Heissenberg, Hund, and Russell has been further extended and a method has been worked out for calculating the higher Rydberg sequence terms of the spectra of any element. The essential modification consists in the writing down of the Stoner levels in the following manner :—

K_1						
2						
	L_1	L_2				
	2	6				
		M_1	M_2	M_3		
		2	6	10		
			N_1	N_2	N_3	N_4
			1,1	(1)	(1)	(1)
				O_1	O_2	O_3
				(1)	(1)	(1)

Stoner diagram for Calcium.

The electrons are allowed to fill the levels and one of the outer valency electrons is allowed to pass through all the higher unfilled levels. Optical terms are calculated by combining the orbit of the running electron with the resultant orbit of the last group of electron, according to the rules laid down by Pauli and Heissenberg. The further rule is laid down that transition is allowed only when the electron moves either horizontally or vertically by one or an odd number of stages. A rough rule is also laid down for fixing up the values of terms arising from any particular combination :—

(*a*) All apparent deviations from the selection principles are successfully explained. Applied to the alkali elements, the theory explains the regular sequence of S, P, D, F values, triplets as well as singlets, in the spectra of Mg, Zn and Cd.

(*b*) Occurrence of large D-terms of the same order of value as are present in the spectra of Ca, Sr and Ba. Large F-terms in Ba are predicted. The anomalous terms discovered by Paschen, and Russell are also explained. A rule is worksd out for the marking out of dashed terms. It is confirmed that the dashed terms are due to the simultaneous jump of two electrons.

14. A note on the spectrum of neon.

MEGHNAD SAHA, Allahabad.

The above considerations have been applied to explain the nature of the spectrum of Neon. It is shown that the terms of the Neon-spectrum are due to the following combination :—

(A) $6L_2$ give us $^1S_0$ discovered by Hertz.

(B) $5L_2$, M_1 give us $^3P_{0,1,2}{}^1P$ which are the same as Paschen's S_2, S_3, S_4, S_5.

(C) $5L_2$, M_2 give us terms

which were first identified by Goudsmit from Zeemann effect data with the Paschen terms, as

$$^1S_0 \quad ^1\overline{P} \quad ^1D \quad ^3S$$
$$^3\overline{P} \quad ^3D$$

(D) $5L_2$, M_3 give us

$$^1P \quad ^1\overline{D} \quad ^1F$$
$$^3P \quad ^3\overline{D} \quad ^3F$$

identified by the present author with the twelve terms which Paschen designated as d's and S's.

Higher Rydberg sequences are also worked out.

15. Relative intensity of X-ray lines.

Y. NISHINA *and* B. RAY, Calcutta.

The recent development of theory of atomic constitution has made measurements of the intensity of the lines of the X-ray spectra very important. Estimates of relative intensities of X-ray lines have hitherto been attempted either by means of ionisation method or by photographic plate. Owing however to the lack of precise knowledge of the relative sensitiveness of these methods for different wave-lengths the comparison of intensities of lines which differ in wave-length has involved considerable uncertainty. To overcome this difficulty absolute measurements of the energy of X-ray lines based on the bolometric method have been attempted by several workers. Since the wave-lengths used lie on the short wave-length side of the Bromine K-absorption edges the sensibility curve for the photographic plate obtained in this way cannot be applied to the measurements of relative intensities of the L- and M-series of most elements. To obtain the sensibility curve we have developed a method which can be used in measuring the relative intensity of the lines in L-series of W. (Nature, Vol. CXVII, page 120.)

A preliminary note on the intensities of lines $La_1 : La_2 : L\beta_1$ was given there. Since then we have measured the relative intensities of other lines in the K- and L-series. In the K-series for copper, nickel, cobalt and iron, the intensity ratio between Ka_1 and Ka_2 is 2 : 1, agreeing with the corresponding lines in alkalies as measured in Utrecht. In the L-series we obtain

$$(a)\ \ a_1 : a_2 : \beta_1 = 9 : 1 : 4{,}7\,;$$
$$(b)\ \ \beta_2 + \beta_x : \gamma_1 = 10 : 4{,}7\,;$$
$$(c)\ \ \beta_3 : \beta_4 = 10 : 6{,}6\,;$$
$$(d)\ \ \gamma_3 : \gamma_2 = 10 : 7{,}5\,;$$
$$\text{and } (e)\ \ l : \eta = 10 : 4$$

as the intensity relation between these lines. Here it will be seen that the analogy with the optical spectra of the alkalies is only approximately obeyed in (a) and (b). Further, it should be noted that intensity rules are only strictly valid so long as the frequency difference of the lines is very small compared with their frequencies. While this condition is fulfilled in the case of doublets of the alkalies, and also in the cases of β_3 and β_4, γ_2 γ_3 in the X-ray spectra, we meet here in the cases α_1 and β_1, β_2 and γ_1, with a frequency difference of 15 per cent. which can scarcely be considered too small. Details are given in the paper.

16. On the irregularity of the K_α doublet in the elements of lower atomic numbers.

D. M. BOSE, Calcutta.

In a recent paper (Phys. Rev., May, 1926) it has been shown that the large and systematic deviation in the separation of the K_α doublets in the X-ray spectra of the lighter elements, from that calculated according to Sommerfeld's relativity formula, can be explained on the assumption that in addition to the difference in the energy of the emitting atom due to the relativity variation in the mass of the radiating electron in its two different orbits, there is also an energy of magnetic coupling between the latter and the atom core, which also alters with the orbit of the electron. For the purpose of calculation it was assumed with Bohr and Lande that only the K-shell in any given atom is endowed with unit magnetic moment measured in term of Bohr's magneton. With help of this last assumption the fine structure of spectral lines and their anomalous Zeeman effect has been explained by Bohr, Lande and others.

Recently an attempt has been made by Goudsmidt and Uhlenbeck

to explain this class of phenomena on the assumption that instead of the K-shell it is the radiating electron itself which is endowed with unit magnetic moment, due to a spin round an axis. In this paper it is discussed how far the irregularity noticed in the previous paper can be explained on the assumption of the spinning electron.

17. On Fresnel's convection coefficient in general relativity.

N. R. Sen, Calcutta.

It is known that if a material medium, which is homogeneous non-conducting and uncharged, be in motion and at the same time the seat of an electromagnetic field then the motion of the medium can be replaced, so far as the electromagnetic tensor F_{ik} is concerned, by a different material tensor connected with the original one by the relation

$$\gamma^{ik}=g^{ik}-(\Sigma\mu-1)v^iv^k$$

ϵ and μ being the dielectric and the permeability constants. If now we assume that any plane electromagnetic (or gravitational) wave is being propagated with a constant velocity in the medium, the integrals of the modified Maxwell's equations furnish certain relations which must be satisfied for the wave propagation. One combination of them leads to a wave a little more complicated than the transverse type of which the velocities of propagation along the line of motion of the medium is given by the quadratic equation

$$(\epsilon\mu-v^2)V^2-2(\epsilon\mu-1)\,.\,v\,.\,V.-(\epsilon\mu v^2-1)=0,$$
$$(1-v^2\neq 0),$$

v being the velocity of the medium and the fundamental velocity being taken to be unity. This gives the velocities of the electromagnetic wave in natural measurements to be

$$\frac{v\pm\frac{c}{n}}{1\pm\frac{v}{cn}},$$

n being the refractive index of the medium. This is really Einstein's Addition Law for two velocities, which leads to the usual value of Fresnel's convection coefficient. Similarly, the motion of the wave transversely to that of the medium has the velocities

$$\pm c\sqrt{\frac{1-(v/c)^2}{n^2-(v/c)^2}},$$

quite in conformity with the restricted theory.

18. On the dualistic nature of the radiation field.

S. N. Bose, Dacca.

The statistical problem of equilibrium of black body radiation in presence of matter has been previously treated by author in two papers in Zt. für Physik. The equation for the elementary process therein deduced can be explained in a simple way, when one assumes that the radiation field has the following dual nature:—

(1) A field in which energy is distributed in definite Quantum units.

(2) The superimposition of the elementary fields of electromagnetic influences from every moving charge gives the second aspect of the radiation field. This microscopic fluctuating electromagnetic field determines the probability of transition, and also the stability of the Bohr orbits.

The above conception seems to give a physical interpretation to the wave mechanical equation of Schrödinger.

19. Stream lines of laminar and turbulent "Grenzschicht."

N. K Bose, Aligarh.

In this paper I have tried to penetrate into the "Grenzschicht" of viscous fluid-motion. First of all a hydrodynamical equation has been obtained which holds true only in the Grenzschicht. Then with certain assumptions of velocity gradient, it has been found possible to integrate the differential equation of the Grenzschicht. The stream lines so obtained in the two cases have been plotted. It has not as yet been possible to compare these with actual photographs of stream lines in laminar and turbulent flow. I hope to compare them in near future.

20. Generation of Karman's vortex-path.

N. K. Bose, Aligarh.

It has been assumed by Prof. von Karman that the layer of discontinuity that exists behind an obstacle in a stream consists of discrete vortices. This assumption is justified by actual photographs. In this paper, I have tried to show that at least in a region which is very close to the obstacle, paths of any one particle of fluid are cycloids, which support the assumption that they form part of a rotating mass of fluid which we call vortex. The investigation fails when we follow the particles some appreciable distance from the obstacle—which is amply justified by experience.

21. Variation of lift of a bi-plane with the angle of attack.

N. K. Bose, Aligarh.

In one of my previous papers read before the Bangalore Science Congress in 1924, I had established a formula for the angle of attack of a bi-plane. In this paper, I have extended this theorem to investigate the Lift coefficient of a bi-plane with reference to its angle of attack. A table has been worked for particular values of aspect-ratio and compared with the figures measured in the Gottingen Aerodynamical Research Laboratory. The coincidence is found to be very satisfactory.

22. Waves in horizontal canals.

B. M. Sen, Calcutta.

The problem of deep water waves in horizontal cylindrical canals has been solved only for canals with plane walls, these being either vertical or inclined at 45° or 60° to the vertical. The velocity potential satisfies the equation

$$\nabla^2\phi=0, \text{ within the liquid} \quad \ldots\ldots(1)$$

$$\sigma^2\phi=g\frac{\partial\phi}{\partial z} \text{ at the free surface, } z=0 \quad \ldots\ldots(2)$$

$$\frac{\partial\phi}{\partial n}=0, \text{ at the walls of the canal.} \quad \ldots\ldots(3)$$

the z-axis being vertical, the x-axis horizontal along the length of the canal, and the y-axis horizontal.

It is easily verified that if we put

$$\phi = P(y, z) \cos kx \, e^{i\sigma t}$$

$$P = \left\{ \cosh \; zD + \frac{\sigma^2}{gD} \sinh zD \right\} - f(y)$$

is a solution of (1), (2), f being arbitrary function of y, and

$$D^2 = k^2 - \frac{\partial^2}{\partial y^2}.$$

One of the values of f for which P can be found in finite terms is $f(y)=y$. We verify that $P=ye^{kz}$ satisfies the condition for the parabolic boundary $y^2=2(z+h)/k$ and the free surface is given by

$$\zeta = -\frac{\sigma}{g} y \cos kx \sin \sigma t, \text{ where } \sigma^2 = gk.$$

We can also find sections appropriate to values of P obtained by putting other values of $f(y)$.

23. Waves in basins.

B. M. Sen, Calcutta.

An obvious extension of the method of the previous paper is to the corresponding 3-dimensional problem, viz. wave-motion in basins. The only known solutions are the cases of rectangular or circular cylindrical boundary with plane bottom.

It can easily be verified that :—

$$\phi = \left[\cos \; z\nabla_1 + \frac{\sigma^2}{g\nabla_1} \sin z\nabla_1 \right] f(x, y)$$

satisfies the equation of continuity and the condition at the free surface, $f(x, y)$ being arbitrary function of x, y.

If we put $f(x, y)=x$, the boundary is given by

$$\left(z + \frac{g}{\sigma^2}\right)^2 = x^2 + \psi(y)$$

where ψ is an arbitrary function of y.

This includes a cone of revolution of semi-vertical angle 45° the corresponding value of ζ being

$$-\frac{\sigma}{g} x \sin \sigma t.$$

Another value which leads to a solution in finite terms (for symmetry about the z-axis) is obtained when

$$\nabla_1^2 f(w) = -k^2 f(w)$$

$$\phi = \left[\cosh \; kz + \frac{\sigma^2}{gk} \sinh \; kz \right] J_0(kw).$$

The appropriate boundary is

$$kw \; J_1(kw) = \frac{A}{\sinh kz + \dfrac{\sigma^2}{gk} \cosh kz},$$

which unfortunately gives a basin of infinite depth. There are two other simple cases where the boundary can be found in finite terms.

24. Hydrodynamical problems connected with turbulent flow in earthern channels.

B. H. Wilsdon, Lahore.

Experiments on the factors entering into the specification of critical conditions, similar to the well-known Reynolds constants, for the flow of water with a free surface, are discussed critically. Empirical rules for the section of earthern channels are referred to the physical factors entering the dimensionless constants determining the critical conditions.

25. A factorable continuant.

Satish Chandra Chakrabarti, Calcutta.

In this paper is given a factorable continuant from which the well-known continuants of Sylvester and Painvin have been deduced as particular cases.

1. The continuant—

$$\left|\begin{array}{cccccc} x+\frac{a^{n-1}-1}{a-1}, & -1 & & & & \\ \frac{(a^{n-1}-1)(a-1)}{(a-1)^2}a^{n-2}, & x-\frac{a^n-a^{n-1}-a^{n-2}+1}{(a-1)a}, & -1 & & & \\ & \frac{(a^{n-2}-1)(a^2-1)}{(a-1)^2}a^{n-5}, & x-\frac{a^n-a^{n-2}-a^{n-3}+1}{(a-1)a^2}, & & & \\ & & -1 & & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & \frac{(a-1)(a^{n-1}-1)}{(a-1)^2a^{2n-4}}, & x-\frac{a^{n-1}-1}{(a-1)a^{n-2}} & \end{array}\right|_n$$

$$=x^n \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad (1)$$

Here the element of the principal diagonal in the r^{th} row is

$$x-\frac{a^n-a^{n-r+1}-a^{n-r}+1}{(a-1)\,a^{r-1}}.$$

This continuant has been evaluated determinantally.

2. If $$\left.\begin{aligned} a&=\frac{a-1}{a^{n-1}-1}\beta_1+\gamma_1+\frac{a^{n-1}+a^{n-2}-1}{a} \\ \beta_r&=\frac{(a^{n-r}-1)(a^r-1)}{(a^{n-1}-1)(a-1)\,a^{2r-2}}\beta_1-\frac{(a^{n-r}-1)(a^r-1)(a^{r-1}-1)a^{n-3r+1}}{(a-1)^2} \\ \text{and } \gamma_r&=\gamma_1-\frac{a^{r-1}-1}{(a^{n-1}-1)a^{r-1}}\beta_1+\frac{(a^{r-1}-1)(a^n-a^{n-2}-a^{n-r}-a^{n-r-1}+1)}{(a-1)a^r} \end{aligned}\right\} (2)$$

then the continuant

$$\left|\begin{array}{cccccc} x+a, & -1 & & & & \\ \beta_1, & x+\gamma_1, & -1 & & & \\ & \beta_2, & x+\gamma_2, & -1 & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & & \beta_{n-1}, & x+\gamma_{n-1} \end{array}\right|_n$$

$$= \left\{ x+\gamma_1+\frac{a-1}{a^{n-1}-1}\beta_1-\frac{a^{n-2}-1}{(a-1)a} \right\} \left\{ x+\gamma_1+\frac{a^n-a^{n-1}-a^{n-2}+1}{(a-1)a} \right\}$$

$$\ldots\ldots \left\{ x+\gamma_1-\frac{a^{n-2}-1}{(a^{n-1}-1)a^{n-2}}\beta_1+\frac{a^n-a^{n-2}-a+1}{(a-1)a} \right\} \quad (3)$$

where the r^{th} factor is

$$x+\gamma_1-\frac{a^{r-2}-1}{(a^{n-1}-1)a^{r-2}}\beta_1+\frac{a^n-a^{n-2}-a^{n-r+1}+1}{(a-1)a}.$$

This continuant is resolvable by means of the same operations as are necessary in effecting the resolution of (1).

3. (i) If $\beta_1=\frac{a^{n-1}-1}{a-1}a^{n-2}$ and $\gamma_1=-\frac{a^n-a^{n-1}-a^{n-2}+1}{(a-1)a}$,

the continuant (3) degenerates into the continuant (1). So (1) is a particular case of (3).

(ii) If $a=1$, from (1) we have

$$\begin{vmatrix} x+n-1, & -1 & & & & & \\ (n-1)\,.\,1, & x+n-3, & -1 & & & & \\ & (n-2)\,.\,2, & x+n-5, & -1 & & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & & 1\,.\,(n-1), & x-(n-1) & \end{vmatrix}_n = x^n$$

This continuant is due to Painvin. We can also deduce his general case. (*Vide infra.*)

(iii) When $a=1$, from (2) we have

$$\alpha=\frac{1}{n-1}\beta_1+\gamma_1+1,\ \beta_r=\frac{(n-r)\,r}{n-1}\beta_1$$

and

$$\gamma_r=\gamma_1-\frac{r-1}{n-1}\beta_1-(r-1).$$

Hence from (3) we have

$$\begin{vmatrix} x+\frac{1}{n-1}\beta_1+\gamma_1+1, & -1 & & & \\ \frac{(n-1)\,.\,1}{n-1}\beta_1, & x+\gamma_1, & -1, & & \\ & \frac{(n-2)\,.\,2}{n-1}\beta_1, & x+\gamma_1-\frac{1}{n-1}\beta_1-1, & -1 & \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & \frac{1\,.\,(n-1)}{n-1}\beta_1, & x+\gamma_1-\frac{n-2}{n-1}\beta_1-(n-2) \end{vmatrix}_n$$

$$= \left\{ x+\gamma_1+\frac{1}{n-1}\beta_1-(n-2) \right\} \{x+\gamma_1-(n-3)\} \ldots\ldots\ldots\ldots$$

$$\left\{ x+\gamma_1-\frac{n-2}{n-1}\beta_1+1 \right\} \ldots\ldots\ldots\ldots (4)$$

the r^{th} factor being $+\gamma_1-\frac{r-2}{n-1}\beta_1-(n-r-1).$

(iv) The nil-factor continuant corresponding to (4) [i.e. the continuant whose matrices may be added to the matrices of (4) without affecting the identity] has been obtained, viz.

$$\begin{vmatrix} (n-1)\xi, & -\xi & & & & & & & & & & \\ (n-1)\xi, & (n-3)\xi, & -\xi & & & & & & & & & \\ & 2(n-2)\xi, & (n-5)\xi, & -\xi & & & & & & & & \\ & & 3(n-3)\xi, & (n-7)\xi, & -\xi & & & & & & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & & & & & & (n-1)\xi, & -(n-1)\xi & & \end{vmatrix}_n \quad \ldots\ldots(5).$$

Adding the matrices of (5) to those of (4) and then in the result—

(α) putting $\beta_1=2(n-1)b$, $\gamma_1=(n-3)b-1$ and $\xi=-b$, we have

$$\begin{vmatrix} x, & b-1 & & & & & & & & & \\ (n-1)b, & x-1, & b-1 & & & & & & & & \\ & 2(n-2)b, & x-2, & b-1 & & & & & & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & & & & & (n-1)b, & x-(n-1) & & \end{vmatrix}_n$$

$$=\{x+(n-1)b-(n-1)\}\{x+(n-3)b-(n-2)\}\{x+(n-5)b-(n-3)\}$$
$$\ldots\ldots\ldots\{x-(n-1)b\};$$

This is the well-known continuant of Painvin [1];

(β) putting $\beta_1=3(n-1)$, $\gamma_1=2(n-3)$ and $\xi=-2$, we have

$$\begin{vmatrix} x, & 1 & & & & & & & & & \\ 1\,.\,(n-1), & x, & 1 & & & & & & & & \\ & 2(n-2), & x, & 1 & & & & & & & \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ & & & & & & & & & (n-1)\,.\,1, & x \end{vmatrix}_n$$

$$=(x+n-1)(x+n-3)(x+n-5)\ldots\ldots\ldots(x-n+1).$$

This continuant was given by Sylvester.[2]

26. A note on the simplification of persymmetric determinants.

M. Venkatarama Ayyar, Bangalore.

In Scott's treatise on determinants, it has been shown that the determinant

$$D=\begin{vmatrix} u_1 & u_2 & u_3 & \cdot & \cdot & u_n \\ u_2 & u_3 & u_4 & \cdot & \cdot & u_{n-1} \\ u_3 & u_4 & u_5 & \cdot & \cdot & u_{n-2} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ u_n & u_{n-1} & u_{n-2} & \cdot & \cdot & u_{2n-1} \end{vmatrix}$$

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[1] Painvin, L. "Sur un certain système d'équations linéaires." *Journ de Math* (2), (iii), (1858), pp. 41–46.

[2] Sylvester, J. J. "Théorème sur les determinants de M. Sylvester." *Nouv. Annales. de Math*, xiii, (1854), p. 305.

$$= \begin{vmatrix} u_1 & \Delta u_1 & \Delta^2 u_1 & \Delta^{n1} u_1 \\ \Delta u_1 & \Delta^2 u_1 & \Delta^3 u_1 & \Delta^n u_1 \\ \Delta^2 u_1 & \Delta^3 u_1 & \Delta^4 u_1 & \Delta^{n+1} u_1 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \Delta^{n-1} u_1 & \Delta^n u_1 & \Delta^{n+1} u_1 & \Delta^{2n-2} u_1 \end{vmatrix}$$

where Δ is the usual difference operator. When u_1, u_2, u_3, etc., are very large numbers, a more effective reduction of the determinant D is obtained by introducing a multiplier k while taking the successive differences as is shown below. This kind of reduction is believed to be new, not being traceable in Muir's History. Form the series of differences thus :—

u_1	u_2	u_3	u_4	. .	u_n
	$u_2 - ku_1$	$u_3 - ku_2$	$u_4 - ku_3$	.	$u_n - ku_{n-1}$
		$u_3 - 2ku_2 - k^2 u_1$	$u_4 - 2ku_3 - k^2 u_2$	. .	$u_n - 2ku_{n-1} - k^2 u_{n-2}$
.	.	.	.	. .	.
.	.	.	.	. .	.

where k is any arbitrarily chosen constant, i.e.

u_1	u_2	u_3	.	.	u_n
$\Delta_k u_1$	$\Delta_k u_2$	.	.	.	$\Delta_k u_{n-1}$
$\Delta^2_k u_1$	.	.	.	.	$\Delta^2_k u_{n-2}$
.	.	.	.	.	.
.	.	.	.	.	.

It is then proved that

$$D = \begin{vmatrix} u_1 & \Delta_k u_1 & \Delta^2_k u_1 & . & . & \Delta^{n1}_k u_1 \\ \Delta_k u_1 & \Delta^2_k u_1 & \Delta^3_k u_1 & . & . & \Delta^n_k u_1 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \Delta^{n-1}_k u_1 & \Delta^n_k u_1 & \Delta^{n-1}_k u_1 & . & . & \Delta^{2n-2}_k u_1 \end{vmatrix}$$

The effectiveness of this reduction is illustrated in some cases of which the following may be given as an instance :—

$$D = \begin{vmatrix} 1 & 5 & 20 & 75 & 275 \\ 5 & 20 & 75 & 275 & 1001 \\ 20 & 75 & 275 & 1001 & 3640 \\ 75 & 275 & 1001 & 3640 & 13260 \\ 275 & 1001 & 3640 & 13260 & 48450 \end{vmatrix}$$, on taking $k=3$,

Reduces in one step to $\begin{vmatrix} 1 & 2 & -1 & 3 & -4 \\ 2 & -1 & 3 & -4 & 8 \\ -1 & 3 & -4 & 8 & -14 \\ 3 & -4 & 8 & -14 & 27 \\ -4 & 8 & -14 & 27 & -51 \end{vmatrix}$

which is readily found to be $=1$.

27. On the coefficients in a certain trigonometric expansion.

M. Venkatarama Ayyar *and* M. Bhimasena Rao.

In a paper on 'Some properties of M-functions' (vide J.I.M.S., Vol. XVI, No. 940), it was shown that

$$\frac{\tan^{-1}x}{\sqrt{1+x^2}}=x-\Sigma 2^2\,.\,\frac{x^3}{\lfloor\underline{3}}+\Sigma 4^2\Sigma 2^2\,\frac{x^5}{\lfloor\underline{5}}-\Sigma 6^2\Sigma 4^2\Sigma 2^2\,.\,\frac{x^7}{\lfloor\underline{7}}+\ldots\ldots$$

with a full explanation of the Σ notation used. In this paper, the series above is shown to be convergent. Then it is established that

$$\frac{\pi}{4}=1-\frac{5}{3\,.\,\lfloor\underline{3}}+\frac{9}{3^2.\,\lfloor\underline{5}}-\frac{3429}{3^3\,.\,\lfloor\underline{7}}+\frac{23481}{3^4.\,\lfloor\underline{9}}-\,.+\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Taking $x=\cos\,\theta+i\,\sin\,\theta$ and separating into real and imaginary parts, results are got like

$$\frac{1}{2}-5\,.\,\frac{1}{\lfloor\underline{3}}+89\,.\,\frac{1}{2\,.\,\lfloor\underline{5}}-\frac{3429}{\lfloor\underline{7}}+\,.\,-\ldots\ldots=\tfrac{1}{2}\left[\frac{\pi\sqrt{3}}{4}+\tfrac{1}{2}\log\,(2+\sqrt{3})\right]\ldots\ldots(2)$$

It is then proved that

$\dfrac{\Sigma(2n)^2\Sigma(2n-2)^2\Sigma(2n-4)^2\ldots\ldots\Sigma 2^2}{(2n)^2(2n-2)^2(2n-4)^2\ldots\ldots 2^2}$ is the $(n+1)\ldots\ldots$convergent of the C.F.:

$$1+\frac{1^2}{2^2}-\frac{2^2\,.\,3^2}{3^2+4^2}-\frac{4^2\,.\,5^2}{5^2+6^2}-\frac{6^2\,.\,7^2}{7^2+8^2}-\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Again, it is shown that

$$\frac{\Sigma(2n)^2\Sigma(2n-2)^2\ldots\ldots\Sigma 2^2}{(2n)^2(2n-2)^2\ldots 2^2}=1^2+\frac{1^2}{2^2}+\frac{1^2\,.\,3^2}{2^2\,.\,4^2}+\,.\,.+\frac{1^2\,.\,3^2\,.\,5^2\ldots(2n-1)^2}{2^2\,.\,4^2\,.\,6^2\ldots(2n)^2}\,..(4)$$

and therefrom it is deduced that

$$1+\frac{\Sigma 2^2}{2^2}\,.\,k^2+\frac{\Sigma 4^2\Sigma 2^2}{4^2\,.\,2^2}\,.\,k^4+\ldots\ldots=\frac{F(\frac{1}{2},\,\frac{1}{2},\,1,\,k^2)}{(k')^2}\ldots\ldots\ldots\ldots(5)$$

where F is the hypergeometric series and k', the modulus complementary to k,

$$=\frac{2k}{\pi}\,.\,\frac{1}{k'^2}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

where k is the real Quarter-period of the corresponding elliptic function.

For

$$k=\frac{1}{\sqrt{2}},\ k\text{ is shown}=\frac{[\Gamma(\frac{1}{4})]^2}{4\sqrt{\pi}}\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

$$\therefore\ 1^2+\frac{1^2}{2^2}\,.\,\tfrac{1}{2}+\frac{1^2\,.\,3^2}{2^2\,.\,4^2}\,.\,(\tfrac{1}{2})^2+\ldots\ldots=\frac{[\Gamma(\frac{1}{4})]^2}{\pi^{\frac{3}{2}}}\ldots\ldots\ldots\ldots(8).$$

28. Evaluation of special persymmetries—Part III.

M. Bhimasena Rao *and* M. Venkatarama Ayyar.

[Parts I and II of this paper were read before the Fifth Conference of the Indian Mathematical Society in April last.]

In this part, the general persymmetric determinants involving the coefficients in the power-series for the M-functions are evaluated in the particular case when each of the elements $a_n=1$, rendering

$$M_n(x)=\frac{n+1}{x}\,J_{n+1}(2x).$$

(The definition and properties of the M-functions, with sufficient explanations of the notations introduced, were read at the last Bombay Science Congress and have since been published in the J.I.M.S., Vol. XVI, Nos. 9 and 10.)

Now $q_n(x)$ is the denominator of the n^{th} convergent of the C.F

$$\frac{1}{x-}\ \frac{1}{x-}\ \frac{1}{x-}\ldots \text{ and } = \frac{\sin(n+1)\theta}{\sin\theta}, \text{ if } x=2\cos\theta.$$

$\therefore$ The numerically distinct roots of the equation $q_{2n}(x)=0$ are

$$x=2\cos\left(\frac{r\pi}{2n+1}\right) \text{ and of } \frac{q_{2n+1}(x)}{x}=0 \text{ are } x=2\cos\left(\frac{r\pi}{2n+2}\right).$$

Also, $$k a_l = {}^{\frac{k+l}{2}}C_{l-1}, [A_0, A_{m-1}]=1, \text{ and } [A_1, A_m]=1,$$

where the rectangular brackets indicate persymmetrics of the m^{th} order, the first and last elements of whose first row or column are enclosed therein.

Again, $$\prod_1^n \sin r\theta = \frac{(2n+1)^{\frac{1}{2}}}{2^n} \text{ when } \theta=\frac{\pi}{2n+1},$$

$$\text{or } = \frac{(n+1)^{\frac{1}{2}}}{2^n} \text{ when } \theta=\frac{\pi}{2n+2}, \text{ and}$$

$$\begin{vmatrix} 1 & \cos^2\theta & . & . & \cos^{2n-2}\theta \\ 1 & \cos^2 2\theta & . & . & \cos^{2n-2}2\theta \\ . & . & . & . & . \\ . & . & . & . & . \\ 1 & \cos^2 n\theta & . & . & \cos^{2n-2}n\theta \end{vmatrix}$$

$$= (-1)^{\frac{n(n-1)}{2}} \cdot \left\{\frac{(2n+1)^{\frac{1}{2}}}{2^n}\right\}^{n-1}, \text{ if } \theta=\frac{\pi}{2n+1},$$

or,

$$(-1)^{\frac{n(n-1)}{2}} \cdot \left\{\frac{(n+1)^{\frac{1}{2}}}{2^n}\right\}^{n-1} \left\{\frac{2^n}{n+1}\right\}^{\frac{1}{2}}, \text{ if } \theta=\frac{\pi}{2n+2}.$$

Using these, the four main results of the first two parts are reduced to results of the type

$$[{}_{2n+1}A_{2n+r},\ {}_{2n+1}A_{2n+r+m-1}] = (-1)^{n(m+r)+\frac{r(r-1)}{2}} \cdot \frac{2^n}{(2n+1)^{n/2}} \times$$

$$\begin{vmatrix} 1 & -1 & .. & (-1)^{2n+r-1} \\ {}_{m+1}C_2 & -{}_{m+2}C_2 & .. & (-1)^{2n+r-1}{}_{m+2n+r}C_2 \\ . & . & .. & . \\ {}_{m+n+r-1}C_{2n+2r-2} & . & .. & . \\ \text{Sin } (2m+1)\theta & \text{Sin } (2m+3)\theta & .. & . \\ . & . & .. & . \\ \text{Sin } (2m+1)n\theta & \text{Sin } (2m+3)n\theta & .. & \text{Sin } (2m+4n+2r-1)\theta \end{vmatrix}$$

These results are applied to several interesting numerical cases and also directly verified. As an illustration, we may mention one example. When $m=1$ (mod. 4).

$$[{}_4A_3,\ {}_4A_{2+m}] \text{ by formula } = (-1)^1 \cdot \tfrac{1}{2} \cdot \begin{vmatrix} m+1 & -1 \\ 0 & -1 \end{vmatrix} = \tfrac{1}{2}(m+1)$$

and taking $m=5$ with the actual values, we get

$$[{}_4A_3, {}_4A_7]=\begin{vmatrix} 1 & 4 & 14 & 48 & 165 \\ 4 & 14 & 48 & 165 & 572 \\ 14 & 48 & 165 & 572 & 2002 \\ 48 & 165 & 572 & 2002 & 7072 \\ 165 & 572 & 2002 & 7072 & 25194 \end{vmatrix} = 3 = \tfrac{1}{2}(5+1)$$

29. A special cubic curve.

M. Venkatarama Ayyar, Bangalore.

Given a triangle ABC, and a point P whose pedal triangle is DEF, it is known that when the triangles ABC and DEF are in perspective, the locus of P is a self-isogonal central cubic passing through 16 notable points, viz., the vertices of the triangle ABC, points diametrically opposite to $A\ B\ C$ on the circumcircle, the in-and excentres, circumcentre, ortho-centre, the points at infinity on the altitudes and the ortho-centre of the antimedial triangle of ABC.

The object of the paper is to express in symmetrical forms the co-ordinates of points associated with P in terms of the co-ordinate of P. The following are some of the results obtained.

1. If Q is the centre of perspective of ABC and DEF, the isogonal conjugate of Q lies on OP, where O is the circumcentre.

2. Let P^1 be the isogonal conjugate of P and Q_1 the centre of perspective of ABC and $D'E'F'$, the pedal triangle of P^1, then the points P, P^1, Q, Q_1, lie on a line passing through the ortho-centre of the antimedial triangle of ABC.

3. If t_1, t_2, t_3, be the tangents from the mid-points of the sides of ABC to the pedal circle of P, then

$$t_1+t_2+t_3=O,$$

showing that the radical axis of the N. P. circle and the pedal circle touches the Stimer's ellipse of the medial triangle of ABC.

4. There exists a point π on the line of collinearity in (2) such that the director circles of the four in-conics through P and π all touch the pedal circle of P.

The co-ordinates of II are shown to be

$$\frac{r_1^2(r_2^2-r_3^2)}{l(m^2-n^2)},\ \frac{r_2^2(r_3^2-r_1^2)}{m(n^2-l^2)},\ \frac{r_3^2(r_1^2-r_2^2)}{n(l^2-m_2)},$$

where l, m, n, and r_1, r_2, r_3, are the normal and tripolar co-ordinates of P.

In particular, we have the result, that the director circles of the inconics through the in-centre or an ex-centre and the corresponding Gergonne point touch the in-circle.

30. The Bakshali manuscript.

A. A. Krishnaswami Ayyangar, Mysore.

We learn from Dr. A. F. Rudolf Hoernle that an interesting manuscript dealing with Arithmetic was found in 1881 near a village called Bakshali in the extreme north-western frontier of India. It is believed to be a composition belonging to the earliest centuries of the Christian era. This view is controverted by Mr. G. R. Kaye in an article published in Vol. VIII of the Journal of the Asiatic Society of Bengal (1912) and according to him the manuscript was not written much before the twelfth century A.D.

This paper contains a re-examination of Mr. Kaye's arguments and shows how his logic is in no way less fallible than Dr. Hoernle's.

31. The Josephus problem and its extension.

A. A. Krishnaswami Ayyangar, Mysore.

In this paper, the author sets forth the mathematical theory underlying the following problem which may be called a generalisation of the well-known Josephus Problem :

N persons are arranged in a circle and the count beginning with some persons in the ring, and A_1th man is first removed, then the A_2th man and so on. The problem is to find the man who will be removed at the r-th count.

W. W. R. Ball remarks that problems like this can be easily solved by counting but it is impossible to give a general rule. The following general formula gives the place, in the initial arrangement, of the r-th man removed, expressed in a notation analogous to the C. F. Notation;

$$\frac{A_r}{N-r+1} + \frac{A_{r-1}}{N-r+2} + \ldots + \frac{A_1}{N}$$

where $\frac{A_r}{N-r+1}$ is a remainder function, the symbols of addition are placed along with the numerators and the zero remainder occurring at any stage is replaced by the corresponding quotient.

The converse of the problem is also studied and applied to some of the unsolved problems of the game of Mouse-trap, elaborated to some extent by Professors Cayley and Steen in the Quarterly Journal of Mathematics 1878 (Vol. XV).

32. On a perspective-criterion for the double contact of two conics.

A. A. Krishnaswami Ayyangar, Mysore.

Starting with the Lemma that if the vertices of two triangles inscribed in a third triangle lie on a conic, there exists an infinite number of triangles inscribed within the conic and in perspective with the three triangles aforesaid, the author establishes the following criterion for the double contact of two conics :

Two conics Σ, Σ' will have double contact, if there exists a triangle inscribed in (or circumscribed about) Σ (or Σ') and in perspective with any two of three triangles $\triangle_1$, $\triangle_2$, $\triangle_3$ two of which (*viz.*, $\triangle_1$ and $\triangle_2$) are inscribed in (or circumscribed about) Σ (or Σ^1) while the third (*viz.*, $\triangle_3$) is circumscribed about Σ^1 (or Σ), $\triangle_1$ and $\triangle_2$.

Numerous corollaries are deduced from the above theorems and the results reveal a remarkable property of the orthopolar ellipse and also the fact that any three directly similar figures in a plane may be so placed that any triad of corresponding points belonging to them is in perspective with the vertices of any specified triangle in the same plane.

Special mention (among the corollaries) may be made of the existence of two circles, one related to a complete quadrangle in such a way that it cuts the three pairs of opposite sides at diametrically opposite points, and the other related to a complete quadrilateral so that tangents drawn to it from pairs of opposite vertices are parallel.

33. On mutually self-polar triangles.

C. V. H. Rao, Lahore.

The paper explains the concept indicated in the title and proceeds to make an application in regard to the theorem of Pappus.

34. Experimental harmonic motions; coupled oscillations Part II.

S. Ganapati Subrahmanyam, Rajahmundry.

Some experiments on harmonic motions were described in the Proceedings of the Indian Science Congress, 1926. The paper gives an account of the subject of coupled vibrations as treated from a mathematical standpoint and also from an experimental standpoint. Previous workers have adopted the photographic method for recording the vibrations. The author here describes a simple method of recording the vibrations in a visible manner. Graphs are exhibitcd.

35. Projection of spectra :—Part III.

S. Ganapati Subrahmanyam, Rajahmundry.

Adopting the arrangement described in previous papers, an account is given for projecting ordinary and extraordinary spectra. This would be an instructive method for beginning the subject of polarisation. This method, as far as the author is aware, is not found in any book.

36. The effect of the dielectric constant on the adsorbability of ions (Part I).

Jnanendra Nath Mukherjee and Subodh Gobinda Choudhury, Calcutta.

In previous papers it has been suggested that one of the effects of non-electrolytes on the precipitation of sols by electrolytes is that the decrease in the dielectric constant brought about on their addition increases the electrical adsorbability of the oppositely charged ion. Experiments have been undertaken to measure the variation in the charge of colloidal particles caused by the addition of electrolytes as affected by the presence or absence of nonelectrolytes. The present paper deals with these results.

37. On the stress and strain in an elastic plate having two infinitely long straight edges under the action of a couple at the corner.

N. M. Basu and H. M. Sen Gupta, Dacca.

In this paper it is shown that the effect of a couple of moment applied at the corner of a thin elastic plate having two mutually perpendicular and infinitely long straight edges is represented by the stress function $x=-L\ sin^2\theta$, θ being measured from one of the edges and the origin being taken as the pole. The stress components as well as the displacements vanish at an infinite distance and the solution is therefore free from the objections to which some solutions of similar problems obtained by distinguished mathematicians are liable. The lines of stress are found to be very simple curves, viz. the orthogonal circles having their centres on the edges and touching the edges at the corner.

38. The resistance of a nickel wire beyond the elastic limits.

Chetan Anand and Dina Nath, Lahore.

An apparatus is designed to provide a self-recording arrangement. When the nickel wire is stretched without turning back, the change in its resistance with stretching is nearly linear up to the breaking point. But

on unstretching the wire and completing the cycle, a closed curve of a peculiar shape (of the type of figure 8) is obtained. The shape of the curve is modified, if the cycle is performed at different extensions.

39. A Poisson's ratio tester.

DURGADAS BANNERJI, Calcutta.

An originally plane surface of metal, resting on knife-edges, when subjected to loading stresses showed different curvatures for the Synclastic and Anticlastic surfaces depending upon the value of the Poisson's ratio of the material. Mallock, Searle, Schiller and others, to whom the determination of the constant for the various substances are due, have used two parallel pins, the relative angular displacement of which in the loaded state gives a knowledge of the curvature in a plane at right angles to the plane of bending. In the present method a lever with a pin fixed normal to it, carries a fixed vertical mirror and the whole system is allowed to travel on the curved surface—the pin making contact with the surface close. The angular tilt of the mirror due to depressions or elevations of the curved surface is measured by the corresponding shift of the illuminated crosswire of a telescope, fitted with a Gauss eye-piece and looking in the direction of the mirror. The dips and elevations of the surface can directly be evaluated by mounting the telescope on a micrometer reading to three hundredth of a centimeter, thus enabling measurement of very slight surface curvatures.

40. On the possibility of the fundamental magnitudes of the second order of a surface being expressed separately in terms of those of the first order and their derivatives.

HARENDRANATH DATTA, Dacca.

In case of some of the surfaces well-known to geometers, the author has expressed the fundamental magnitudes of the second order *separately* in terms of those of the first order, and their derivatives by taking the lines of curvature, conjugate lines, or null lines as parametric curves. This shows that the general contention (without proof) that the fundamental magnitudes of a surface cannot bear such relations is *not* correct.

The first result of this type was obtained by the author in connection with his paper on "Surface with plane lines of curvature, Part II" (see *Proc. Benares Math. Soc.*, Vol. IV).

41. On a problem of rolling motion.

HARENDRANATH DATTA, Dacca.

In view of the difficulty of applying Lagrange's method to the problem of pure rolling, Appell made use of Euler's geometrical equations in his discussion of the motion of a body bounded by a surface of revolution (and dynamically symmetrical about the axis of revolution) rolling without sliding on a rough horizontal plane, and reduced the whole problem to the solution of 18 equations in as many quantities. He has also shown that, in the special case of a body rolling on a sharp edge (like that of a circular cylinder with a plane bottom, or a hoop), the solution requires the integration of

$$\frac{d^2r}{dv^2}+\cot v\frac{dr}{dv}+\frac{MCa}{AC+M(Aa^2+Cc^2)}(c\cot v-a)r=0$$

(see 312 of A. G. Webster's *Dynamics of a particle, etc.*), the notations being the same as in Webster's book.

In the case of the hoop for which $c=o$, the reduced form of the above

equation has been integrated by Appell in terms of *hypergeometric functions.* In this paper, the author has integrated the general equation ($c \neq o$) in terms of *Riemann's P-functions* which, as we know, can be connected with *hypergeometric functions.*

42. Efficiency of musical instruments.

R. N. Ghosh and B. Majumdar.

(Communicated by Dr. Megnad Saha.)

Defining efficiency of musical instruments as the ratio of output to input of energy per second, $E = A/I$ the efficiency of organ pipes has been found. The output of the instrument is calculated from the measurements of the energy density i in a room by the formula $A = avi/_4$ where a=velocity of sound, and i was measured by Rayleigh's suspended disk method. In the particular case of an organ pipe of frequency 256, A was found to be $1.21\ t\ 10^2$ ergs per second. I was measured by the rate of flow of air, the pressure and the aperture of the mouth piece E came out to be of the order of 10^{-2}. More accurate measurements of the input and output at various pressures are in progress.

43. Acoustics of the pianoforte.

R. N. Ghosh.

(Communicated by Dr. Megnad Saha.)

It is well known that the tone quality, and the dissipation of the sound, are different from different keys of the pianoforte. The present paper gives a theoretical calculation of the forced vibration of the sound board when the vibration of the string is supposed to be known. As regards the tone quality of the string it has been shown that the fundamental, and the octave have maximum amplitude when $(2/\pi)(ml/M\alpha)^{\frac{1}{2}} = 1$ or 2, where m=mass of the string of length 1, M=mass of hammer, and α the striking distance. So that for the same value of α and the particular ratio given by the above relation, the tone quality of the string will remain the same in each key, but (1) the forced vibration of the sound board depends upon the nearness of the period of vibration of any component of the sound board to that of the string, and (2) the rate of decay of energy of the string for the above component is very great, and it dies out quickly. Thus we find that as we pass from one string to the other, the quality of sound from the sound board alters in character ; and further for the same string the quality changes after a short interval of time because of the rapid decay of a particular component. Incidentally the effect of vibration of the sound board upon the period of free vibration of the string has been evaluated ; it is found to be greater, the nearer is the free vibration of the sound board to that of the string.

44. On the solution of two problems of central orbits, by the method of vectors.

K. Khastgir, Chittagong.

The paper deals with the solution of two well-known problems of central orbit by the method of vectors. The first problem discussed is the converse of Kepler's second law. It has been proved vectorial ly that when the rate of description of area is constant the force acting on the particle is a central one

In the second problem, the law of force under which a particle describes an elliptic orbit with centre of force either at the centre or at the focus has been obtained.

45. Geometrical interpretation of the invariants of a pair of bilinear forms.

A. Narasingha Rao, Madras.

By regarding the di-gradient variables x (x_1 x_2 .. x_n) and y (y_1 y_2 y_3 .. .. y_n) as the homogeneous co-ordinates of points in two spaces X and Y of order n (or dimension $n+1$) a bilinear form $A=\Sigma a_{rs}\ x_r\ y_s$ equated to zero establishes a one-one correspondence of points in one space and hyperplanes (flat regions of order $n-1$) in the other. The *Invariants* of two such forms A and B are the co-efficients θ_{rs} in the expansion

$$|\ \lambda a_{rs}+\mu\ b_{rs}\ | =\Sigma\ \lambda^r\ \mu^s\ \theta_{rs} \quad [r+s=n]$$

It is shown that these invariants vanish when certain incidence relations hold between the two simplexes in either space which correspond to the same simplex in the other, in the two correlations $A=o$ and $B=o$.

46. Fine structure of spectrum lines.

Wali Mohammad *and* S. B. L. Mathur, Lucknow.

The fine structure of spectrum lines is attracting great attention as it throws light on the constitution of matter and the nature of mechanism involved in the production of spectra. The work done so far is confined to the lines in the visible spectrum and very little is known about the lines in the other regions.

The arrangement used by the authors is the same as used by Wali Mohammad, viz., an arc in vacuum, a Quartz Lummer Gehrcke plate and a Quartz Spectrograph. The Structure of several lines in the Ultra-violet region ranging from $\lambda=4{,}800$ to $\lambda=2{,}600$ of Zinc and Cadmium has been investigated and measurements given for these lines.

47. A note on Quincke's method of finding the surface tension.

Tribhuwan Prasad Gaurgas.

(Communicated by Mr. Satyendra Ray.)

A difference from the accepted value of the surface tension of mercury obtained in an actual experiment by the author, that was too large to be explained away by the errors of experiment, lead the author to an examination of the theory of the experiment. It is shown that except unde r the condition of the drop being a very large one, and of the drop bein symmetrical about the vertical section through the vertical tangen experimentally observed, the furmula employed is not valid. An approx imate expression for the correction is obtained.

48. A note on the variation of pitch with amplitude.

William Chowfin.

(Communicated by Mr. Satyendra Ray.)

It is shown that theoretically the pitch should decrease with decay of amplitude and not increase, as sometimes recorded. The decrease in pitch is easily perceived subjectively with a monochord or an Indian *ektara* by concentrating attention on the fundamental. Recent experiments in U.S.A. Bureau of Standards support the theoretical considerations submitted in the paper.

49. On the nature of discharge through a neon tube.

Binda Prasad Srivastava *and* Krisna Gopal.

(Communicated by Mr. Satyendra Ray.)

During Ray's experiments on the change in wave-length by passage of light through an absorption filter, and on the converision of line spectra into continuous ones under specific values of concentration, the authors examined the Neon tube discharge by means of a rotating mirror. With the Neon tube capillary and the axis of the rotating mirrors vertical the discharge got drawn out into a flag-shaped band. The band was composed of a number of parallel sine curves inclined to the horizontal over which was superposed a number of parallel dark bands. With change in the direction of discharge the inclination of the sine curves to the horizontal was reversed. The effect is sought to be explained by the hypothesis of mass motion of charged atoms under the powerful intermittent electric force. The Doppler effect was experimentally verified with the spectrometer.

50. Change of wave-length by transmission through a thickness of transparent glass.

Satyendra Ray.

As early as 1924 the author from theoretical considerations sought to obtain evidence of change of wave-length due to passage through a length of glass. It was first tested with a constant deviation spectrometer but without success. Rhodamine and methyl violet filters were then attempted with the Michelson's interferometer with very satisfactory results. During attempts to photograph this effect as well as the Bhar effect by making it stationary by the arrangement described in Journal of Scientific Instruments of August 1926, p. 386, the silvering of the half silvered plate was found to have entirely disappeared. After some time, when the plates were dispatched to Adam Hilger for resilvering, the interferometer was fitted up with the Fabry and Perot interferometer attachments. With the high resolving power thus obtained the effect first sought to be found with the wave-length spectrometer was again sought. A small but distinct break with parallel horizontal fringes was obtained when a glass cube of 2 inch side was put behind the plates so as to cover half the field of view.

51. On the possibly spurious character of the "fine structure" of lines and of the "continuous spectrum" of hydrogen, etc.

Satyendra Ray.

The result mentioned in Abstract 50 has obviously a bearing on the "fine structure" of lines. In the Lummer and Gehrcke plate successive pencils travel through successively increasing lengths of glass and should possess a specific value of λ each. The "fine structure" may be nothing more than this difference in the wave-length of the different pencil elements revealed by the resolving power of the optical system.

An elementary investigation is made showing that the separation of the "fine structure" elements would increase rapidly with decrease of wave length. This would make study of fine structure in the ultraviolet region extremely profitable. The recorded results, however, do not seem at first sight to justify this hope. Theoretical considerations and experimental evidence are submitted for explaining this experimental discrepancy.

The result mentioned in Abstract 49 and accepted for publication by Phys. Zeit. on the conversion of line spectra into continuous one may

have some bearing on the continuous spectra of elements. The glass wall is an absorbing medium, and certain specific lines by passage through the glass walls themselves or through the material of the prism may be converted into a continuous spectrum.

Without in any way questioning the explanations extant of these two phenomena it is submitted that the probability of their being "manufactured" in the way indicated here is not completely ruled out of order.

52. Oscillations of audible frequency produced in a neon lamp.

G. R. Paranjpe.

Connecting a suitable condensor in parallel with a Neon Lamp, and using the usual supply mains of 230 volts. D.C., it is possible to produce regular audible oscillations. Similar to the method of substitution for determining a resistance, the pitch of these Neon Lamp oscillations can be conveniently employed to measure by substitution values of unknown capacities and self-inductances. The circuit in its simplest form serves as a very instructive demonstration experiment.

53. Use of carbonic acid gas in mercury interrupters.

G. R. Paranjpe *and* H. D. Tendulkar.

It is customary to use coal gas as a dielectric for quenching the spark in mercury turbine interrupters. A series of experiments carried on Hydrogen and Carbonic Acid Gas indicate that the efficiency of the interrupter is greatest with hydrogen and least with coal-gas, as regards the current and E.M.F. output in the secondary. It is also more economical to use Carbonic Acid gas than coal gas as regards the power consumed in the primary for a given intensity of the X-radiation. It appears, therefore, that Carbonic Acid gas can be more advantageously employed in interrupters in such X-ray hospitals where coal gas is not available.

54. On the origin of the movements of camphor on water and other allied phenomena.

L. A. Ramdas, Simla.

The movements of small particles of camphor, antipyrin and a large number of soluble organic compounds on water are commonly explained as recoil effects or as due to differences in the rate of solution of the substance at various points over the boundary. In this paper a different theory in which the movements are related to the form of the stream-lines of flow of the material along the surface is put forward.

Most organic compounds, whether *solid* or *liquid*, when brought in contact with a clean surface of water, spread as mono-molecular films. These films quickly disappear by solution or evaporation. When a large quantity of the substance (as a lump or lens as the case may be) is present, the spreading is continuously maintained. Streams of the material leave the edges and the stream-lines are found to be convergent when the boundary is concave and divergent when it is convex. In the former case the surface-films are denser and their tension smaller than in the latter case, as shown by actual measurement. As a consequence, forces are set up which cause the dissolving particle or droplet to move away from the concave boundary.

For example, when lenses of amyl alcohol float on water, they are found to distort in shape and to move away from the concave side, the movements, however, stopping when the water below gets saturated and evaporation is prevented. Similar effects are observed with camphor blocks having concave edges on one side and with paper strips of similar shape moistened with amyl alcohol or even oleic acid.

In the case of particles of dye-stuffs thrown on clean water, it is found by microscopic observation that *micro-crystals* of appreciable size are rapidly shot off from particular points on the boundary. In this case the movements of the parent crystals are due to recoil and often exhibit beautiful spiral forms. Some dye stuffs such as methyl violet produce liquid films and exhibit rapid movement while others, such as tetriod-fluorescein give solid films which do not permit such rapid movements of the crystal. When touched by an oiled wire, a liquid film of dye-stuff is swept off but a solid film exhibits radiating cracks. A particle of dye-stuff, when thrown on a surface of water contaminated by oil, refuses to spread and immediately sinks leaving behind a beautiful trail.

Mono-molecular films on water are made visible directly by the increased light-scattering power of the surface and in some cases as for instance, tetriod-flourescein, by the intense fluorescence under strong illumination. The transmitted beam is visibly coloured owing to absorption.

55. Some measurements of the ellipticity of light reflected at the free surfaces of liquids at the Brewsterian angle.

L. A. Ramdas, Simla.

The ellipticity of light reflected at the free surfaces of a large number of pure liquids has been accurately determined. The thickness of the "transition layer" at the surface, calculated from the fresh data according to Drude's theory, comes out to be of molecular dimensions and suggests that the ellipticity arises from the roughness of the surface due to molecular agitation.

56. The scattering of light by gaseous mixtures at high pressures.

L. A. Ramdas, Simla.

The intensity of light transversely scattered by pure oxygen, carbon-dioxide and their mixtures in various proportions for pressures ranging from 20 to 120 atmospheres at 32°C, has been measured in terms of the scattering by liquid ethyl alcohol. Some polarisation measurements have also been made for pure oxygen and unsaturated carbon-dioxide. The intensity for pure oxygen is proportional to the pressure, whereas for mixtures of increasing percentage of carbon-dioxide, the intensity-pressure curves tend to become more and more similar to the curve for pure carbon-dioxide for which the intensity increases much more rapidly than the pressure. At pressures greater than a few atmospheres, the intensity of scattering ceases to be a linear function of the percentage volume of CO_2 in the mixture.

57. The Barkla-Effect with scattered X-radiation (the J-phenomenon).

S. R. Khastgir, Calcutta.

In the investigation on scattered X-radiation, described in the present paper, the J_1 J_2 and J_3 series of absorption edges and lines in various substances (e.g. paper, aluminium, copper, silver, tin and gold) have been demonstrated. These involve what has generally been called the J-transformation of an X-radiation.

The characteristics of this transformation—conveniently called the Barkla-Effect in this paper—are briefly the following :—

(1) There are definite critical values for mass-absorption-coefficients at which these J-absorption edges and lines appear. The critical value is

different for different absorbing substances. It is *characteristic* of the absorbing material.

(2) The magnitude of Barkla-Effect is also different for different substances.

(3) The effect is conditional on factor or factors other than wave-length and the material of the absorbing substance.

(4) On the assumption that a change of wave-length is always associated with a change of absorption in *all* substances, the Barkla-Effect does not involve any change of wave-length during transmission.

(5) The effect is definitely associated with an *average* absorption-coefficient and *not* with a certain wave-length of the radiation.

The application of all these generalisations to scattered X-radiations has led to some very important conclusions. The main conclusions are:

(1) The difference that is generally observed between the penetrating powers of the primary and secondary (scattered) radiations is due to the fact that the scattered X-radiation shows the Barkla-Effect, while the primary does not, in passing through the absorbing substances, used to test the absorbability of the radiations. The differences appear abruptly at the critical penetrating powers for the Barkla-Effect. Apart from these differences, distinctly associated with the testing material, the scattered and the primary radiations are exactly alike.

(2) Between two discontinuities, the difference between the mass-absorption-coefficients for the primary and secondary radiations is constant, viz.:

$(\mu/\rho)_2 - (\mu/\rho)_1 = \text{constant}$. The constant depends only on the material of the absorbing substance. According to the Compton-Debye theory on the contrary, the change in wave-length for a definite angle of scattering should be constant.

(3) Since the Barkla-Effect is conditional on factor or factors other than the nature of the substance traversed and wave-length of radiation, there is *either* an equality of the penetrating powers of the primary and secondary radiations *or* a marked difference between the two. The "modified" and the "unmodified" scattering are not therefore, *simultaneous* but only *alternative*.

(4) The difference between the penetrating powers of the secondary and primary radiations, is independent of the angle of scattering. This again is contrary to the theory of change in wave-length proposed by Compton and Debye.

The results seem totally incompatible with the Compton-Debye theory of scattering. The possibilities of reconciling these results with the spectroscopic work of Compton and others, are discussed in detail.

58. The action of magnetic field on the refractive index of carbon dioxide gas.

P. N. Ghosh *and* P. C. Mahanti, Calcutta.

A. Glaser (Ann. d. Physik, 75. pp. 459—488, and 78 pp. 641—658) in determining the susceptibility of diamagnetic gases noticed that under a definite magnetic field the susceptibility decreases proportional to the pressure decrease. For a certain pressure range however there is a deviation from the above law, and the law of variation instead of being linear follows a prabolic form, and that both above and below this range the linear law has different gradients.

Fraser (Phil Mag. April 1926 pp. 858-890) failed to notice any change in the refractive index, when the gas is subjected to a magnetic field of about 184 gauss along the direction of propagation of light within a pressure range of ·001 to 8m/m. E. Lehrer (Ann. d. Physik 81,19,) also did not notice any variation of pressure with the application of magnetic field with the help of a delicate optical manometer.

The present authors have noticed a decided change in the optical path of pure dry CO_2 gas when subjected to a constant magnetic field of 3,600 gauss acting transversely to the direction of propagation of light and the pressure gradually increasing from 10–400 m/m. Michleson type of interferometer was used and all optical parts as well as the base plate were tested to be non-magnetic. The maximum change was noticed in the pressure range 300–350 m/m, nearly in the same region in which the departure from the linear law was noticed by Glaser. Moreover the relation between the pressure and the fringe shift follows parabolic law.

This shows a decided anisotropy in the optical path of the molecules of the dipolar gas of the type of CO_2.

59. Convergence of certain multiple series and integrals.

K. S. K. Iyengar, Bangalore.

The object of this paper is to discuss the convergence of the series

$$\Sigma\Sigma\Sigma(m_1w_1+m_2w_2+\ldots)^{-s}$$

and the corresponding integral

$$\int\int\int\int\frac{dx_1.dx_2\ldots dx_r}{(x_1w_1+x_2w_2r\ldots)^s}$$

and their main properties. The results obtained are :—

I. (1) If λ is an anteger >0 conveniently chosen and

$$|\,Km_1m_2m_r\,| \leqq K_1 \text{ a constant};$$

then

$$\sum_{\lambda}^{m_1}\sum_{\lambda}^{m_2}\ldots\sum_{\lambda}^{m_r}\frac{1}{(m_1w_1+m_2w_2\ldots)^s}-\int_{\lambda}^{\eta vr}\ldots\int_{\lambda}^{m_1}\frac{dx_1\,.\,dx_2\ldots dx_r}{(x_1w_1+\ldots x_rw_r)^s}$$

$$=\sum_{\lambda}^{m_1}\sum_{\lambda}^{m_2}\ldots\sum_{\lambda}^{m_r}\frac{Km_1m_2m_r}{(m_1w_1+m_2w_2+\ldots)^{s+1}}.$$

(2) The series is absolutely convergent for R(s) > r

(3) When r is an even integer, i.e., $r=2\rho$; then

$$Lt.\left\{\sum_{-m_1}^{m_1}\sum_{-m_2}^{m_2}\ldots\sum_{-m_{2\rho}}^{+m_{2\rho}}\frac{1}{(m_1w_1+\ldots m_{2\rho}w_{2\rho})^{2\rho}}\right\}=\frac{\log f(u_1,u_2\ldots u_{2\rho},w_1\ldots w_{2\rho})}{(2\rho-1)!\;w_1\,.\,w_2\ldots w_{2\rho}},$$

if $m_1,m_2\ldots m_{2\rho}$ tend to infinite so that

$$\frac{m_1}{\mu_1}=\frac{m_2}{\mu_2}=\frac{m_3}{\mu_3}=\ldots\frac{m_{2\rho}}{\mu_{2\rho}}$$

and f is a rational Algebraic function of the several variables involved

(4) Considering the series in two dimensions

$$Lt.\sum_{-m_2}^{m_2}\sum_{-m_1}^{m_1}\frac{1}{(m_1w_1+m_2w_2)^2}=C+\frac{1}{w_1\,.\,w_2}\log\frac{(\mu_1w_1-\mu_2w_2)}{(\mu_1w_1+\mu_2w_2)}.$$

as $$m_1\rightarrow\infty,\ m_2\rightarrow\infty.$$

and $$\frac{m_1}{m_2}=\frac{\mu_1}{\mu_2},$$

Hence we derive the well known result in the theory of elliptic functions

$$\eta_2\omega_1-\eta_1\omega_2=\pi i/\wp.$$

where $\zeta(u+2w_1)-\zeta(u)=2\eta_1\,;\ \zeta(u+2w_2)-\zeta(u)=2\eta_2,$

after the usual notation.

II. Discussion of the series

$$\Sigma\frac{a_{mn}}{(m+wn)^s}$$

Let $\overset{m}{\Sigma}\overset{n}{\Sigma}A_{mn}=S_{mn}.$

If $\dfrac{S_{mn}}{(m+wn)^2}\underset{m,n,\to \text{ is}}{\to}K.$

and if $f(s)=\overset{\infty}{\underset{1}{\Sigma}}\overset{\infty}{\underset{1}{\Sigma}}\dfrac{A_{mn}}{(m+wn)^s}.$

then $\underset{s\to 2}{Lt.}\ f(s)(s-2)=K^1.$

where K' is a constant depending on K

Results of a similar type are also obtained.

60. Predetermination of the voltage distribution on a string of suspension insulators.

G. Yoganandan, Bangalore.

Considering the string of suspension insulators to be a case of distributed capacities, voltage distributions and gradients are obtained for the following cases:—

1. Equal capacities of all the elements of the string to earth and capacities to line negligible.
2. Equal capacities to earth and equal capacities to line.
3. Capacities to earth negligible and the capacity of any element of the string to line varying inversely as its distance from the line.
4. Equal capacities to earth and capacities to line varying as in case 3.

Curves of voltage distribution and gradient are drawn for different ratios of earth-to-self and line-to-self capacities.

Two of the ways of obtaining uniform distribution of potential are (*a*) to grade the capacities of the elements of the string, (*b*) to use a shield of the proper shape on the line. The conditions for constant gradient in (*a*) and (*b*) are obtained in the form of equations.

The effects of voltage, leakage resistance and length of chain on the voltage gradient are considered.

Section of Chemistry.

President :—Prof. H. K. Sen, M.A., D.I.C., D.Sc. (Lond.).

Presidential Address.

Ladies and Gentlemen,

There is a note of sadness in the proceedings of to-day, missing, as we shall henceforth do in our midst, the familiar figure of a zealous worker of our science, a great teacher and a kind friend, the late Prof. E. R. Watson, whose sympathies and co-operation are now for ever removed from all our chemical activities by the cruel hand of death. Speaking for myself, and I have not the least doubt for all of us, I might say that Prof. Watson was undoubtedly one of the founders of the School of Chemistry in India, and the rich memory he has left enshrined in our hearts will far outlive any monument that we may raise hereafter. As he inspired while he lived, so will the fragrant reminiscences be deep as Life! With a solemn hush for the memory of the departed great, let us then begin to-day's work.

When a few months back the Executive Committee of the Congress invited me to conduct the deliberations of the Chemical Section, I confess I was genuinely glad, though thoroughly conscious of my personal limitations. I was glad because it would give me the opportunity, as it has done to-day, of placing before a most representative body of chemists in India the question of the activation of chemical study and research from a realistic point of view. Allow me, therefore, first to thank you heartily before I proceed.

The comparative infancy of scientific organisations in India naturally leaves the field of applied science as yet practically unexplored in almost all its branches. Of these, however I have specially chosen the fuel problem as the text of to-day's discourse, as I have no doubt you will agree with me that although this is the most fundamental problem of all ages, very little scientific work of any consequence has been undertaken in this direction in this land of sunshine. It is true that the question, so far as India is concerned, is not in a sense so acute to-day; but the time is within sight when we shall be faced with a situation not unlike that in Europe or America. Forewarned is forearmed, and the fundamental unity of the problem all over the world makes it a universal subject of the foremost importance. It is only natural, therefore, that I should restrict myself to a review of the successful application of our science to power production, and it is clear also that if I were to propose to enumerate all the important developments that happened during the last twelve months even in this limited region, I would most assuredly fail.

I would crave your indulgence, therefore, for the inevitable omissions, which I need hardly point out, are to be traced to the limitations of my subjective sense, and to the customary time-limit, rather than to any disregard of their importance. The bearing of this problem of power on locomotion and agriculture it is not necessary to dilate upon, and the constantly increasing need for a study of the physico-chemical conditions of efficient power production, as well as those of lubrication, corrosion, etc., shows the interdependence of the chemical and the engineering sciences, and indicates the difficult and comprehensive nature of a present-day chemist's vocation. A comparison of the complex equipment of a modern chemical laboratory, as for instance, those of the Kaiser Wilhelm Institute in Berlin, or the Royal College of Science, London, or to come even nearer home, those of the Indian Institute of Science, Bangalore, with what one reads of the equipment of Liebig's or Bunsen's or even Baeyer's laboratories, would serve to demonstrate very clearly the appreciation of the intimate relationship between the two sciences. Heat which was at first considered to be the only agent for the acceleration of reactions, has now amongst its allies factors like pressure, catalysts, etc., to bring about chemical changes mostly unthought of only two decades ago. Limitations of glass vessels were long felt, the outcome of which are the resistant wares of to-day. In fact, these improvements have opened newer fields of research, alike theoretical and practical in consequence. I am anxious to lay more stress upon this latter aspect, as I feel the great and noble work unfolded by the ceaseless toils of the master minds of our science, will have found a just recognition and a real habitation if only their implications were followed up and made into living truths by application for the benefit of humanity.

With the instinct and desire for greater comfort and leisure in life, man has been forced to develop this machine age, and hence in all his undertakings, ancient methods of power generation are being daily outstripped and supplanted by more efficient chemical and physical means One almost feels that we are thus heading for a period of utilisation of the energy of atoms! The primitive method of cultivation by man and animal power is largely at a discount, and with the progress of civilization, the cry for substitution of this by mechanical power is becoming more and more insistent everywhere. This craving has led man to look for an unlimited supply of power on the one hand, and made him cautious as to how he spends his stored energy on the other. Thus to-day, whilst we are striving to utilise the current energy of the Sun, the problem of the economical use of the already existing fuels is being exhaustively studied as one of immediate practical importance. In India, however, not one establishment exists for the development of this important aspect of our coal and forest industries,

faced though the former is with a severe depression now. I have no doubt, enterprises in this direction will spring up to save the industry from collapse, but to combat competition and increase the value of coal and its bye-products, it is not legislation alone, but intensive research work that is absolutely necessary.

The power problem, therefore, may be broadly divided under two headings: (1) the economic utilisation of our existing fuels, and (2) the development of methods for the utilisation of the current solar energy. The third important source, the hydro-electrical one, being a problem mainly mechanical in nature, I should perhaps leave out of consideration in a conference of chemists. It would probably be convenient to indicate at this stage the sequence in which I propose to discuss the whole subject—first, the use of fuel for *automotive power*. secondly, for heating effects in boilers, evaporators, etc., and thirdly, for metallurgical and allied operations. Whilst the first depends upon how much of the thermal capacity of the fuel is convertible into mechanical power, the latter two are dependent on conduction, convection and radiation.

The economic utilisation of existing fuels.—The wastefulness of burning solid fuels as such is so very apparent that in the face of an impending shortage of fuel, wherever local conditions would permit, there could be hardly any justification for such thoughtless combustion. The economy that arises from the use of liquid and gaseous fuels, has led numerous workers to investigate the problem of gasification and liquefaction of coal. The greatest bulk of work in technical chemistry centres round this point, as will be evident from the perusal of a single copy of an industrial journal. Indeed, there probably does not exist a more fascinating study both from the engineering as also from the chemical point of view. The probable shortage of petrol has switched off the attention of investigators on coal products from the orthodox high temperature carbonisation to the problem of increasing the liquid products from coal. Two processes, both as yet in an experimental stage, have thus been the outcome of efforts (*a*) to create a motor fuel from coal, and (*b*) to produce such a coke as will burn readily on our ordinary gratings without smoke. First, the *low temperature carbonisation*, the history of which so far as Great Britain is concerned, may be divided into two periods—the one beginning from 1906, consequent upon the suggestion of Parker, and the second, with the commencement of the World War. Naturally the demand for fuel oils led to the investigation of the low temperature carbonisation process in all its details, with the consequence that the problem emerged from its original comparatively unimportant position, and became a national question. Prominent amongst English workers were Parker, Sir George Beilby, Maclaurin, and a few others. Whilst their attention

was almost entirely engrossed with the production of smokeless fuel during the first period of investigation, the advent of the War brought the importance of the tar oil into greater prominence. The Committee of the Privy Council for Scientific and Industrial Research, led by the urgency of fuel oil in particular, and fuel conservation in general, established in 1917 a Board of Fuel Research with the late Sir George Beilby as Chairman. The results of the work of the Board at His Majesty's Fuel Research Station at East Greenwich up to 1922, show that "owing to economic changes which have come about as the result of the war, the solution of the problem has proved more difficult on the economic side than was anticipated." The vast amount of useful data that have, however, accumulated as a result of experimentation, has placed us in a more favourable position to develop the future of the industry with less costly mistakes. Considerations that were scarcely regarded as significant, are now recognised to be essential for success. Thus the selection of suitable coals for low temperature carbonisation appears to be by far the most important factor, and the original suggestion of Parker to use iron retorts, which seemed to be unsuitable because of the non-observance of this point, is now being revived again. The formation of a robust coke which is so necessary from the domestic point of view, and which very seldom was attained in the beginning, led to the importance of preparing a coal for carbonisation. As is well known, even in a single coal, bands of varying fusibility exist, and as such the materials must be broken down and intimately mixed to impart the necessary cohesion to the mass as a whole. If the coal is deficient in binding material, a correct proportion of some suitable coal must be added to secure this robustness of final coke. A very significant factor that accounted for the failure of earlier processes, was the attempt to devise a single apparatus capable of handling shales, cannels and coals. This distinction not having been realised, no retort could be perfected, and the innumerable data are more or less valueless from the economic point of view. The chief objects of low temperature carbonisation are:—

(i) The production of smokeless fuel suitable for domestic and other purposes;
(ii) The maximum production of oil of low specific gravity;
(iii) The maximum production of gas of high calorific value.

As the quantity of fuel gas generated by low temperature carbonisation is even less than half of what is obtained by high temperature retorting, its special properties and high calorific value should be expected to compensate for this deficiency to no inconsiderable extent. The following table

gives an average result of carbonisation with increasing temperature :—

I. Yield of gas and tar per ton of coal carbonised.

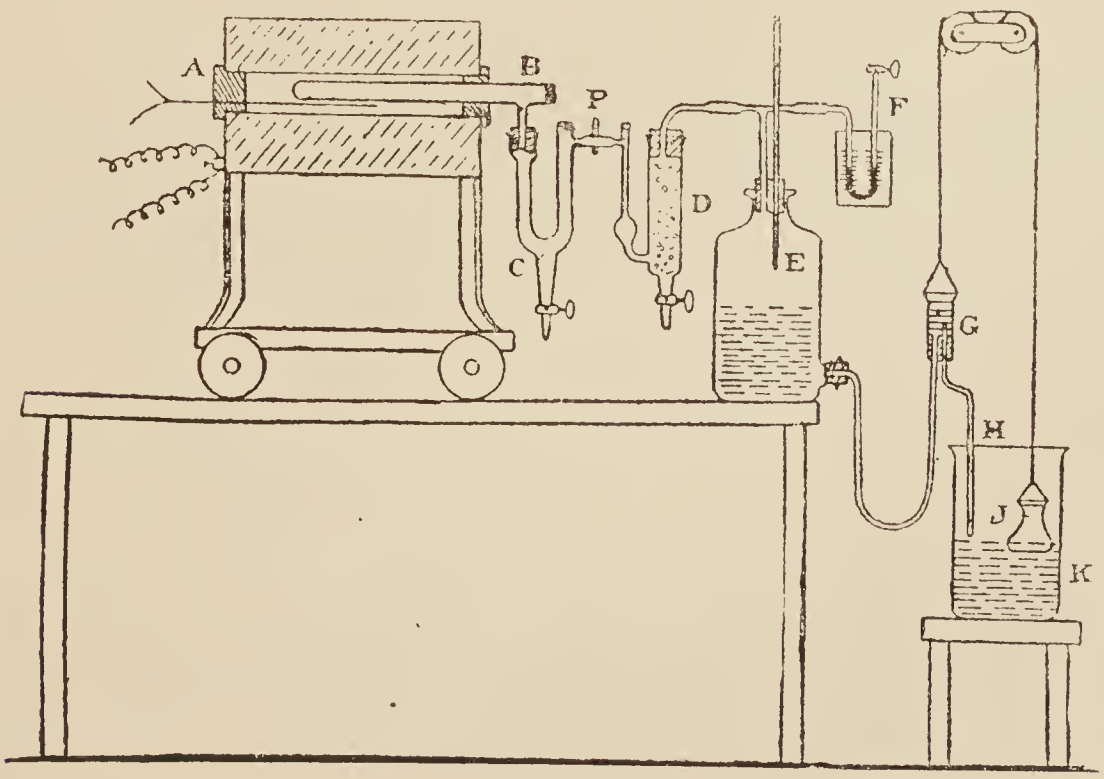
Temperature of distillation. °C	Volume of gas in c. ft.	Tar in gallons.	Specific gravity of tar.
900	11,000	9	1·2
800	10,000	12	1·17
700	9,000	15	1·14
600	7,750	18	1·115
500	6,400	21	1·087
400	5,000	23	1·06

II. Effect of temperature of carbonisation on the percentage proportions of the chief constituents of the Gas :

Temperature ..	400°C	500°C	600°C	700°C	800°C	900°C
Hydrogen ..	21·2	28·3	33·8	41·6	48·2	54·5
Saturated hydrocarbons ..	60·1	56·2	50·7	45·0	39·1	34·2
Unsaturated hydrocarbons ..	6·3	5·8	5·0	4·4	3·8	3·5

It would appear that the gas is only 5,000 c.ft as against 11,000 c.ft. by high temperature retorting, but the candle power is over 20, and the calorific value about 750 B.T.U. Excepting sulphuretted hydrogen, other sulphur compounds are so low as to satisfy most sticklers for purity.

It is instructive in this connection to point out the relation between laboratory assay and full scale results obtained with coals subjected to low temperature carbonisation. A suitable laboratory apparatus for the purpose, which is used at His Majesty's Fuel Research Station is that devised by Gray and King, based on a method used in the Scottish Shale Oil Industry. The complete apparatus is given below :—



The most significant part of the apparatus is the ingenious device for maintaining the pressure constant during the carbonisation. As the gas enters the gas-holder E, it drives the liquid into G through a piece of india rubber tubing. Consequently, there is an overflow from G which collects in the reservoir K on which a counterpoise J floats. J and G are connected over pulleys by a chord. When, therefore, the level of liquid in K rises, the vessel G is automatically lowered ; and if E and K have equal cross sectional areas, a constant pressure is maintained in the holder E.

The table below gives a comparison of yields by laboratory assay (L) and by large scale operations in horizontal retorts (H) :—

Comparison of Yields obtained in low temperature Laboratory Assay (L) and Horizontal Retorts (H) expressed as parts per ton of dry coal.

Coal.	Langley Brights Tupton Seam.	Dalton Main Hards. 1	Dalton Main Hards. 2	Mitchell Main Gas Nuts.	Elistown Main Breeze.	Mean Ratio, Horizontals: Laboratory.
Coal (dry) ..	100·0	100·0	100·0	100·0	100·0	
Coke (cwts.)—						
L ..	14·66	14·83	15·38	15·38	14·61	
H ..	14·76	14·86	15·77	15·72	15·22	
Ratio H : L ..	1·01	1·00	1·02	1·02	1·04	1·02
Tar (gallons)—						
L ..	28·2	30·4	2·50	26·8	21·5	
H ..	16·5	17·0	1·40	16·25	12·9	
Ratio H : L ..	0·59	0·56	0·56	0·60	0·60	0·60
Liquor (nett gallons)—						
L ..	12·3	8·4	10·1	7·85	17·9	
H ..	17·15	11·55	11·7	6·95	17·1	
Ratio H : L ..	1·39	1·38	1·16	0·89	0·96	1·18
Ammonium Sulphate (lb)—						Mean ratio with
L ..	17·4	4·35	4·80	4·80	9 6	suitable
H ..	..	3·6	4·18	2·73	8·45	scrubbing
Ratio H : L ..	..	0·83	0·87	0·57	0·88	1·0
Gas (c. ft. at 30° & 60°F. satd.)—						
L ..	3770	3770	3370	3510	3450	
H ..	3600	3770	3150	3480	3480	0·96
Ratio H : L ..	0·95	1·00	0·94	0·99	0·95	

It will be noticed that the ratio (H : L) is practically unity in all cases, except in the case of tar oils where only 60 per cent. of the figure obtained from laboratory assay is reproduced in large scale operations. This is undoubtedly due to some cracking taking place in large scale operations,

where the vapour remains in contact with the heated surface of the coal or of the retort for a much longer time. This points to the danger of accepting laboratory figures for tar oils, and to the need for a reliable conversion factor. In drawing up the following typical tentative balance sheet, therefore, the oil yield should be put at 15 gallons per ton of coal and not 20 gallons, as is usually maintained :—

Expenditure.	English cost.	Indian cost.	Income.	English price.	Indian price.
	£ *s.* *d.*	Rs. A. P.		£ *s.* *d.*	Rs. A. P.
Coal, 1 ton ..	1 10 0	10 0 0	Coke 14 cwts.	1 10 0	10 8 0
Cost of carbonising (labour, maintenance and fuel for heating) ..	0 4 0	3 0 0	Oil 15 gallons @ 5*d.* ..	0 6 3	4 11 0
Interest and depreciation @ 20 per cent. ..	0 4 0	3 0 0	Gas 30 therms @ 4*d.* ..	0 10 0	7 8 0
	1 18 0	16 0 0		2 6 3	22 11 0

Balance : 8*s.* 3*d.* or Rs. 6 As. 11 per ton of coal carbonised or 41% profit on cost of plant.[1]

A remarkable process for completely liquefying coals has been conceived and realised by Franz Fischer, Director of the Kaiser Wilhelm Institute for Coal Research at Mulheim. The coke after low temperature carbonisation is at first converted into water-gas which is finally liquefied to "methanol" (methyl alcohol) under great pressure in presence of zinc oxide as catalyst. An equally fascinating process for the liquefaction

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[1] It may be argued that considering Indian conditions, there would hardly be any outlet for the gas, for the present at any rate. The profit of low temperature carbonisation would, therefore, have to be found in the sale of coke and tar oil alone. In the table above, both coke and oil have been rated very low. If reasonable prices for these are taken for calculation, and the pitmouth price of selected grade Indian coal allowed at Rs. 6 per ton, then the table above would show as below :—

Coal, 1 ton	6 0 0	14 Cwts of Coke @ 10/8/- per ton	7 6 0
Cost of carbonising (labour, maintenance and fuel for heating) ..	3 0 0	Oil @ 7 As. per gallon ..	6 9 0
Interest and depreciation @ 20 per cent. ..	3 0 0		Rs. 13 15 0
	Rs. 12 0 0		or Rs. 14/- approximately.

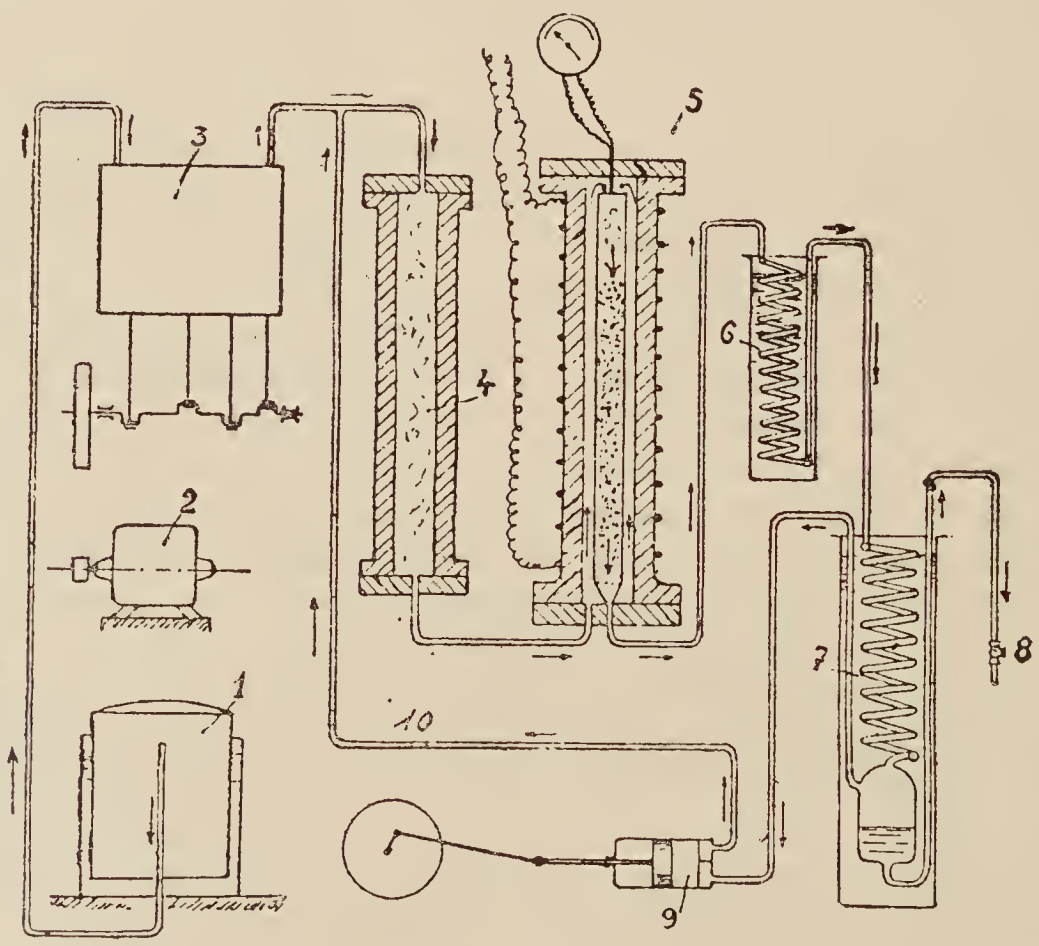
This shows a balance of Rs. 2 per ton. The cost of a plant handling 100 tons a day is about 4·5 lacs of rupees : nett profit on the capital outlay is therefore 13% approximately.

of coal, but with better promise to my mind from the industrial point of view, has been elaborated by Bergius for the direct conversion of coal or lignite into motor and Diesel oils to the extent of 50 per cent. of its weight, by subjecting coal to a pressure of 150 to 200 atmospheres in the presence of hydrogen, and at a temperature of about 450 deg. C. The yield of oil has been in some instances reported to be as high as 85–90 per cent. of the weight of coal, but for a technical run, Bergius himself claims that one ton of crude oil can be produced from 2 tons of coal for 30 shillings covering interest on investment, amortization, repairs and labour for a plant in England. The economic aspects of the two processes depend upon so many factors that a critical examination of the processes in all their details can only inform us as to their technical feasibility, neither having at the present moment emerged from the experimental stage. It is reported that several groups interested in low temperature carbonisation have found no difficulty in disposing of their tar at a price of 1*s.* per gallon This figure, on the very face of it, is very optimistic, as fuel oil from foreign sources is available at 4*d.* a gallon. No doubt this could have been due to the special quality of low temperature tar oil which the ordinary petroleum fuel does not possess, but for our purpose it would be unwise to reckon the price of the low temperature oil at more than 5*d* per gallon. To lay more stress on the oil part of this industry at this stage, specially of our Indian conditions, would be inexpedient, as the selective demand for this commodity will depend upon so many other factors, whilst the smokeless fuel industry may be reasonably expected to have a market far surpassing any that fuel oil may command. From the world point of view, however, the question of the production of motor oil is more urgent. A report of the Department of Commerce of the U.S.A., estimates that on January 1st of 1926, 24,589,249 motor cars and trucks were in operation throughout the world. Calculating on an average that each car consumes 400 gallons of motor fuel per year, the total fuel consumed by the automotives would be $400 \times 24,589,249$ gallons. It is evident from this figure, that if the gasoline type of liquid fuel is to continue as the source of automotive power, the chemist will have soon to find some means of converting solid into liquid fuel. Thus, both Fischer's process and that of Bergius have far-reaching influence on the power problem of the future. In a very interesting paper published in the Gas Journal by H. Nielsen (1926, 174, 591-592; 650–653; 732–734) the question of the economic conversion of coal into oil by low temperature carbonisation, the Bergius process, and Fischer's 'synthol' process, have been critically examined. He summarises by stating that the Bergius process is essentially a cracking process. The Fischer and Tropsch "synthol" process

(Ber., 1924, 152, 1001) is the most efficient method at present available for the conversion of coal into oils. The latter consists in (*a*) low temperature carbonisation in the "L and N" retort and (*b*) use of the coke as a source of water-gas and conversion of the latter into "synthol," a mixture of higher alcohols, as distinct from "methanol." Nielsen, however, seems to have overlooked one special feature of the Bergius process, namely, that it is a more direct route than the others, and does not involve expensive gas purification processes, or the use of easily poisoned catalysts. The report of a Bergius plant at Manheim-Rheinau, having a capacity of 4 cubic meters and capable of dealing with 18,000 tons of raw material per annum, does not justify Nielsen's estimate (F. Schuster, Sparwirtsch, 1925, 3, 157). The process is illustrated by the following results: 1 ton of dry coal, with an ash content of 4 per cent., yielded 210 Kg. of gas, 455 Kg. oil, 75 Kg. of water and 5 Kg. ammonia. The residue was carbonised and gave further 25 Kg. gas, 80 Kg. oil and 240 Kgs. Coke. In all 535 Kg. of oil were obtained which, on fractionation, yielded 150 Kg. of refined benzine, 200 Kg. of Diesel oil, and 60 Kg. of lubricating oil. The residue served as fuel oil. Nielsen's contention that the percentage of lubricating oil in the Bergius product is negligible cannot, therefore, be maintained, if 60 Kg. of lubricating oil have really been obtained by the Manheim-Rheinau plant. The wide applicability of "berginisation" is further exemplified by E. Laszlo (Petroleum, 1926, 22, 421–425) who states that from 100 Kg. of Italian lignite mixed with 63 Kg. of topped coal tar and 4 Kg. of "Lux," berginised at 470 deg. under 140–150 atmospheres in a 50 litre bomb by the continuous method with the addition of 5 Kg. of hydrogen, 8 Kg. of water-white benzine having an odour of petroleum benzine were obtained, 84·6 per cent. of which distilled over from 50 to 120 deg. C. A very recent communication from Bergius shows that from 1 ton of dry upper Silesian gas coal, 140 gallons of crude oil were obtained, which, on distillation and refining, yielded 40 gallons of motor fuel, 50 gallons of Diesel engine oil, 35 gallons of fuel oil, a pitch residue, and 10,000 to 12,000 cft. of gas The washing loss was only 1 per cent. and the gasoline consisted of 3·1 per cent. unsaturates, 7·6 per cent. aromatics, 51·7 per cent. naphthenes, and 37·6 per cent. paraffins. This composition exhibits excellent "antiknock" properties. The variety of use to which berginisation oil can be put may be gathered from the composition of the spirit obtained from Orgreave washed slack (Ormandy and Craven, J. Institute of Petrol. Tech., 1926, 12, 77-78):

Unsaturated compounds	3·1 %	*iso*Heptane, etc.	2·9 %
Benzene	2·7 ,,	*n*-Heptane	6·5 ,,
Toluene	1·9 ,,	*cyclo*Pentane	0·8 ,,
Xylenes, etc.	2·9 ,,	Methyl*cyclo*pentane	4·5 ,,
Butanes, *iso*Pentanes, etc.	10·8 ,,	*cyclo*Hexane	10·3 ,,
n-Pentane	10·5 ,,	Methyl*cyclo*hexane	11·4 ,,
*iso*Hexane, etc.	6·3 ,,	Residue	15·4 ,,
n-Hexane	10·0 ,,		

It would thus seem that if the economic aspect of berginisation is not as encouraging to-day as that of Fischer's Synthol process, the reason probably lies in the imperfect development of the technical side. In this respect Fischer's process had a start, as the plant used for the conversion of CO and H mixture to methanol or synthol is practically the one used in Haber's synthesis of ammonia. In fact, we shall presently see that there is a very close fundamental chemical analogy between the ammonia process and the methanol process. There can be no doubt that the Bergius process, being a single stage operation, is more fascinating and likely to prove a commercial success.



Methanol Plant

In both these processes for obtaining motor oil from coal, the use of high pressure is indispensable. A principle of very fundamental character has thus been developed in our Chemical Science for the realisation of these reactions,—the suppression of the decomposition of the new molecules formed by the use of high pressure. It is this oversight which

accounts for the failure of that master conjurer in catalysis, Sabatier, to realise elementary reactions like—

$$CO+H_2=CH_2O, \text{ or } CO+2H_2=CH_3OH.$$

In all hitherto known carbon monoxide reactions at ordinary pressure, the reduction with hydrogen leads to the final product methane, and not to formaldehyde or methyl alcohol. For a long time, therefore, the search for a proper catalyst capable of converting water-gas into intermediate reduction products, appeared to be the only course left. A probable clue to the secret of carbon monoxide reduction was found in the difference of behaviour on heating between potassium formate and zinc formate. K. A. Hofmann showed about 9 years ago that whilst potassium formate forms readily by the interaction of carbon monoxide and potassium hydroxide at ordinary or low pressures, zinc formate is produced from carbon monoxide and zinc oxide at considerably higher pressure. The former yields, on decomposition, potassium oxalate and hydrogen, whilst the latter gives formaldehyde, methyl formate and methanol. The residue, of course, is zinc oxide which can regenerate zinc formate from carbon monoxide. Although these facts exercised no small influence on the choice of zinc oxide as catalyst, its function in the actual synthesis of methyl alcohol from carbon monoxide and hydrogen is by no means clear. Audibert seeks to explain the action of ZnO by assuming that at first a suboxide is formed which acts as a hydrogen carrier. This is in analogy with the action of finely divided nickel, a hydride of which has actually been isolated by Schlenk. As no such compound of zinc is yet known, there is room for other plausible explanations, most of which are concerned with the generation of moisture by the reaction, as *zinc hydroxide* and not *zinc oxide*, is necessary for the realisation of the formate reaction :

$$Zn(OH)_2+2CO=(HCOO)_2Zn.$$

All that can at present be stated is that using zinc oxide as catalyst, both Patart and Fischer (and Tropsch) obtained methanol in almost theoretical yield. The indispensable use of high pressure (150 atmospheres) was warranted by the already known fact that below red heat zinc oxide decomposes methanol readily into carbon monoxide and hydrogen, and it was by working on the expectation that the same catalyst under high pressure might induce the reverse reaction, that success followed. The facts, however, can be readily anticipated from Le Chatelier's principle, as according to it, the increase of pressure should shift the equilibrium to the right hand side of the balanced reaction :

$$CO+2H_2 \rightleftarrows CH_3OH.$$

Although this work is one of the highest synthetic interest, yet, so far as motor fuel is concerned, methanol is not particularly suitable. This is evident from the fact that its heating value is the least of all its homologues. Fischer and Tropsch realised this shortcoming of the process, and extended it to the synthesis of mixed higher alcohols, "Synthol," by using excess of hydrogen in the methanol synthesis. Contrary to their own expectation and results reported by the Badische Anilin und Soda Fabrik Patents of 1913-1914, practically no hydrocarbon, but a mixture of higher alcohols and ketones with small amounts of aldehydes and acids was obtained. The Badische process was conducted with an excess of carbon monoxide, using pressures over 100 atmospheres and a temperature of 360 to 420 deg. The catalyst was iron impregnated with basic substances, the final product being mainly hydrocarbons. The most favourable temperature for synthol production is 400–420 deg., the pressure 150 atmospheres, and the catalyst is iron filings impregnated with strong bases, the hydrogen being kept in excess. Both these actions have been explained by Fischer as below :—

$CO + C_6H_{13}OH = CO_2 + C_6H_{13}.H = CO_2 + C_6H_{14}$

$CO + 2H_2 = CH_3OH$

$CH_3OH + CO = CH_3 \,.\, COOH$

$2CH_3 \,.\, COOH = CH_3 \,.\, CO \,.\, CH_3 + H_2O + CO_2$ (side reaction)

$CH_3 \,.\, COOH + H_2 = CH_3CHO + H_2O$

$CH_3CHO + H_2 = C_2H_5OH$

$C_2H_5OH + CO = C_2H_5COOH$, and so on.

The chief importance of synthol lies in its use as light motor fuel, as practically 87 per cent. of the crude product distils below 200 deg. C. But the yield is as yet low, precluding general technical use. The technical importance of methanol arises primarily out of its use for denaturation of ethyl alcohol, methylation of organic compounds, manufacture of dimethyl aniline and of formaldehyde. The Bakelite industry alone requires several thousand tons annually, and the ever-increasing prospect of synthetic resins will no doubt cause greater and greater demand. Lormand who reported the results obtained by Patart, the French Inspector General of the Bureau of Explosives, on the catalytic synthesis of methanol, gives the following cost for producing 26 gallons in a plant of 7·5 tons daily capacity :—

Raw materials—	Francs.
150 Cu.m. of water gas @ 0·16 Franc per Cu.m.	.. 24
67 Cu.m. of hydrogen @ 0·25 Franc per Cu.m.	.. 16
Overhead charges	.. 65
Yield 26 gallons. Total	.. 105

Worked out on gold basis a gallon costs 9*d* to 13*d*.

Lormand further remarks that "an important consideration, from the economic point of view, would be the simultaneous manufacture of methanol and formaldehyde, since, by decomposition of methanol in accordance with the equation $CH_3OH = CH_2O + H_2$ the hydrogen liberated could be immediately used."

The production of methanol had increased so far that at the end of 1923, the Merseburg Plant of the Badische Anilin und Soda Fabrik was manufacturing 10–20 tons of the product a day, whilst during the first quarter of 1925, 122,906 gallons worth 56,422 dollars were sold in the U.S.A. The methanol problem is thus very interesting both for the theoretical as also for the technical chemist. It is a question of significance to the tariff expert, the banker, the economist or the public.

I feel tempted at this point to digress in order to draw your attention to and stimulate your interest in arrangements for high pressure catalytic reactions, which have so far not been attempted in India. But I fear my time would hardly permit it. I would, therefore, only refer to that highly instructive contribution on this matter by F. A. Ernst of the Fixed Nitrogen Research Laboratory, Washington, D.C., that appeared in the July issue of 1926 of Industrial and Engineering Chemistry, and pass on.

We have so far seen, therefore, that the "synthol" process or the Bergius process has reached a sufficiently advanced stage of development for either to be carried on to commercial success under the stimulus of a petroleum shortage. I cannot pass on to the consideration of steps that petroleum manufacturers themselves are taking to defer this shortage, without referring to an unlimited field of research in Chemical Engineering, that lies in the utilisation of powdered coal in internal combustion engines. This venture is already reported to have gone beyond the merely experimental stage in certain German manufactories of Diesel engines, and in fact, the idea is far from being new, as Diesel himself originally started with this notion. His oil-injection engine was a later idea. In any case the portable gas producers using charcoal or special low temperature coke have already been built by a few european manufacturers and road tests have already proved the fuel cost to be 1/6th to 1/8th that of gasoline. It is obvious that disadvantages of the producer for automotive requirements are many: *Loss of time in starting, low overload capacity, and inadaptability to varying power requirements, removal of dust and tar from the gas,* make it unfit for certain obvious purposes, but in constant load, steady speed and continuous operation services, it will probably soon assert its superiority. By combining such automotives with the gasoline system, many of the disadvantages may, however, be removed, and in fact, if this

can be achieved, most of the synthetic liquid fuel processes will remain in abeyance. This is very important from the Indian standpoint also. A reference to "colloidal fuel" in this connection is pertinent.

Returning now to the process of "cracking": Mr. W. C. Teagle of the Standard Oil Company of New Jersey is sponsor for the statement that "during the last three years, gasoline was produced more cheaply from cracking than from the initial distillation of the crude oil, and in this way, by utilising distillates, 144 million barrels of cracked gasoline were produced. To have produced this 144 million barrels of cracked gasoline from the initial distillation of 'crude'..... would have necessitated the running of 585 million barrels of crude. Thus the cracking process during the past three years, actually conserved this 585 million barrels of crude which is in excess of the total quantity of crude now in storage in the U.S.A." Mr. Teagle mentions 5 cents per gallon as the cost of the cracking process, and looks for further development in this line.

We have thus seen how the coal and oil industries are intimately related to each other, and how their scientific control is a matter of economic necessity. This scientific control relates not only to the problem of finding better chemical means for transformation of one fuel into another, but also to the development of more efficient application. In fact it is on the "availability" of the energy of fuel that often real economy lies, and not so much on the calories contained therein. This will be evident from the well-known thermal values of gasoline and alcohol. Whilst the latter has a calorific value slightly above half that of petrol, the mechanical efficiency of alcohol engines can be improved by increasing the compression ratio to such an extent, that the lower thermal value is compensated for *almost* to the point of superiority of alcohol as a fuel.

This is a valuable consideration, as alcohol, whether 'fermentation' or synthetic, may in a short time take its place as a motor fuel, if indeed it is not already being used in certain quarters. Whilst the economics of various fuels and increase of over all efficiency by the use of "anti-knocks" may be left out of consideration for the present, the other aspect of fuel application, namely the evolving of thermal energy as distinct from mechanical energy, is probably far more important on account of the universality of its character. At a meeting of the Institute of Civil Engineers held on March 5, 1926, Sir Philip Dawson said that the fuel bill was a dominant factor in total cost of industrial production. It is 35 per cent. in the iron and steel industry, in the generation of electricity as high as 50 per cent., and is from 30 to 45 per cent., of the total locomotive costs on railways. Here again, two distinct

types of heating are to be taken into consideration: the one, where securing of a maximum amount of thermal energy of the fuel is the objective, and the other, where the attainment of very high temperatures is of the first importance. For both purposes, the use of gaseous and liquid fuels has been adopted in all rationally conducted establishments, and with the appearance of improved burners, oil firing is daily gaining prominence. The latest improvement in the process of firing which has been receiving commercial recognition, is due to Bone, who described his "flameless incandescent surface combustion" at the Royal Institution in 1911 in the following words: "A homogeneous mixture of gas and air in the proper proportions for complete combustion or with slight excess thereof, is allowed to flow under slight pressure through a porous diaphragm of refractory material from a suitable feeding chamber, and is caused to burn without flame at the surface of exit, which is thereby maintained in a state of red hot incandescence. The diaphragm is mounted in a suitable casing, the space enclosed between the back of the casing and the diaphragm constituting a convenient feeding chamber for the gaseous mixture which is introduced at the back. The Bonecourt diaphragm which was the outcome of Bone's collaboration with the late C. D. McCourt (who laid down his life in the service of his country. before he could perfect his diaphragm), did not however achieve commercial use, due to frequent or uncertain back-firing. But Mr. Cox, by his persistent efforts, made the diaphragm a success. The essential difference between the two systems of diaphragm-making is, that while Bone made it of equal sized granules or granules increasing in size from back to front, Cox used smaller and smaller granules from back to front, in building up his combustors. The action of the Cox diaphragm or 'Combustor' as he calls it, is due to the interspacing of small separated granules of refractory material in front and larger ones at the back, in two or more layers of differently graduated sizes of granules, which themselves individually are not porous to air or gases, and each of which, therefore, when heated, transmits the heat by molecular vibration alone from the surface towards the centre. Consequently, a granule of small diameter will become heated throughout its mass to a higher mean temperature in a shorter time than a larger granule. In other words, in unit time, more heat is dissipated in molecular vibration in the mass of a given weight of the smaller granules than in the same weight of the larger granules and the higher the degree of radiancy, the more rapid the combustion of fresh supplies of gas and air-mixture, up to a point when the mixture passes over the flowing surface of the granules too rapidly for its complete true surface combustion. There are, therefore, limiting factors as regards the relationship between time of surface contact (which

is a function of pressure and velocity of the mixture), the surface per pound of the granules at any point in the cross-section of the combustor, and the mean porosity of the combustor itself. The whole question of successful manufacture and perfect functioning hinges upon the surface-per-pound weight of the combustor at any part of its section in a plane at right angles to the radiant surface.

As regards the general economics of surface combustion, many users are recording savings of from 20 to 60 per cent. in their consumption of gas, thus resulting in cheaper heating than even by raw coal, taking all other factors into consideration. A further interesting feature is, that in factories where it has been installed, and in Welfare Canteens the medical officers have noted a very marked improvement in health of the workers since its installation, and in one factory where the authorities had considered it to be necessary to put in a new ventilating system, this was found eventually unnecessary after surface combustion had been installed. The process of surface combustion should engage the serious attention of the housewife and the industrialist alike, as it is easily and economically applicable to (*a*) the raising of steam or the heating of water, (*b*) the heating of houses, offices, etc., (*c*) cooking, (*d*) drying and evaporating, (*e*) metallurgical work, and (*f*) crematoria.

We shall now pass on to the consideration of the second important factor, namely, the attainment of high temperatures in industrial processes. The higher temperature obtainable by hydrocarbon oil burning has not probably been given the importance it deserves, although a fair amount of work has been done on the temperature of flames. The determinations of temperature were carried out with simpler gas flames and were extended to the calculation of hydrocarbon-flame temperatures by the speaker in 1925, without the knowledge of an investigation on somewhat similar lines by Goodenough and Felback (March, 1924).

To arrive at a value for the temperature of a *flame* as distinct from *the equilibrium temperature of a furnace*, the following considerations were made use of :—

When a fuel burns, the thermal energy that is liberated raises the temperature of the products of combustion to an extent depending upon the specific heats of the latter. As the temperature rises, the products of combustion, however, begin to dissociate. This dissociation derives the necessary thermal energy from the fuel itself, and in consequence, the temperature of the flame is lower than what would have been the case, had there been no dissociation. Besides, with increased temperature, the specific heat varies also considerably, a correct value of which is necessary for calculation of flame temperatures. The determination of specific heats beyond certain high temperatures is impossible due to limitations of vessels and as

such, physical methods are in some instances taken advantage of. In our calculations, we have used Langen's values for the mean molecular heats of gases at different temperatures. Let us now for simplicity assume that we are burning pure carbon and let $H_1(T)$ represent the quantity of heat absorbed by the dissociation of CO_2 at the temperature T, x being the fraction dissociated.

Then, $$H_1(T)=qx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where q represents the heat of formation of CO_2 from CO and O. Further, let $H_2(T)$ be the heat utilised in raising the temperature of CO_2, CO and O to T deg. (absolute). This quantity is equal to $Q—H_1(T)$, where Q represents the heat of formation of CO_2 from C.

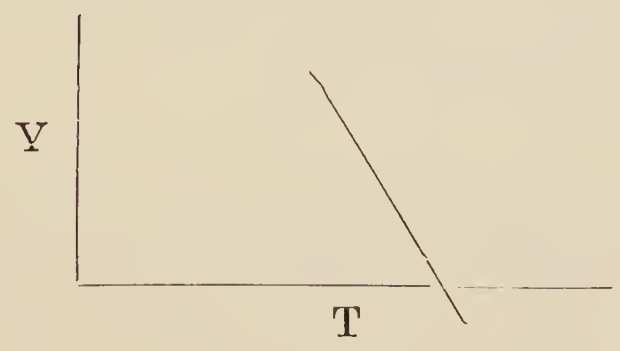
Then,

$$H_2(T)=Q-H_1(T)=T\left\{(1-x)S_{CO_2}+xS_{CO}+\frac{x}{2}S_O\right\} \ldots . (2)$$

where S represents the specific heats of the gases at the temperature T. For the combustion of hydrogen into water, the same notations with H′ may be employed, using appropriate values for q, x, and Q. Now, in order to find the value for T, the equation (2) will have to be solved graphically. This would give the temperature of a carbon flame. The interpretation of the equation is that there must be found one temperature at which the degree of dissociation x and the specific heats have such values that the relation

$$Q-qx-T\left\{(1-x)S_{CO_2}+xS_{CO}+\frac{x}{2}S_O\right\}=0=Y \ldots\ldots (3)$$

is valid. In other words, if the temperature and the value of the equation (3) be represented by the abscissa and the ordinate respectively, then the point at which the curve intersects the temperature line will be the solution of the equation, because at this point alone, the value of the equation (3) is equal to zero.



In arriving at the value of x for CO_2 at different temperatures, use has been made of the equation,

$$\log K = \frac{29580}{T} - 2{\cdot}44 \log T + 0{\cdot}00074\ T - 2{\cdot}609 \ldots (A),$$

the value 2·609 for the thermodynamically indeterminate constant being taken from Haber's data (Zeitschrift für physikalische Chemie, 1909). As the dissociation of CO_2 may be represented by

$$2\ CO_2 \rightleftarrows 2CO + O_2,$$

$$K \text{ (the dissociation constant)} = \frac{x^3 - 3x + 2}{x^3} \ldots\ldots\ldots\ldots (4)$$

We can now tabulate two sets of data : one, the value of K at different temperatures directly from the equation (A), and another, the value of K with different values of x from equation (4), whence, as is obvious, the relation between x and T may be found out. Having now obtained values for x at different temperatures, we can solve the equation (3) graphically as described above. It would appear now that by combining the equations for carbon-oxygen and hydrogen-oxygen flames, and neglecting the water-gas reaction for the sake of simplicity, the temperature of the hydrocarbon flame may be likewise calculated. Here the equation will have the form,

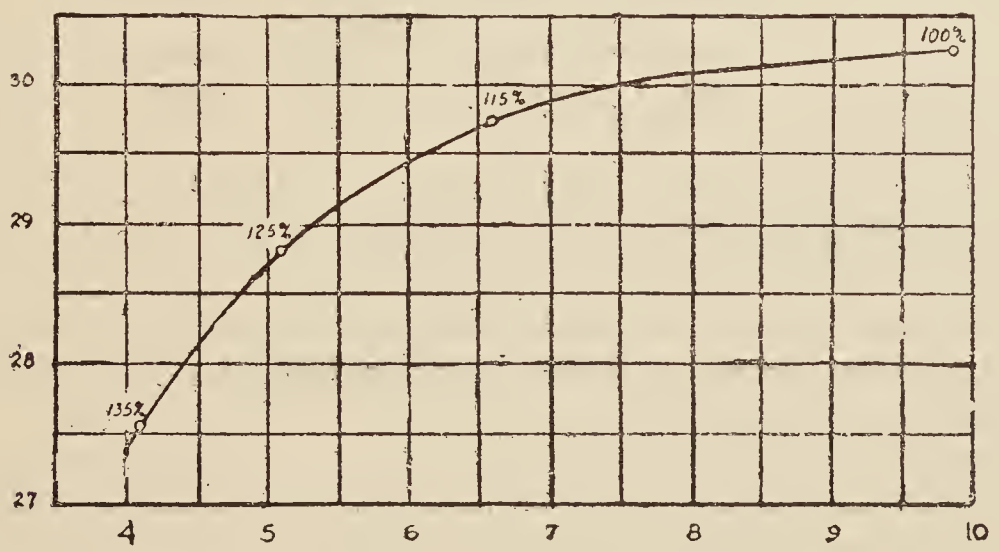
$$H_1(T) + H_2(T) + H'_1(T) + H'_2(T) - (Q + Q') = Y = 0.$$

Thus, a hydrocarbon of 84·0 per cent. carbon, and 14 per cent. hydrogen content, with 2 per cent. of sulphur and residues, when burnt with the requisite quantity of oxygen, gives a flame of temperature 3375 deg. absolute (approx). Below is a table of calculated absolute temperatures:

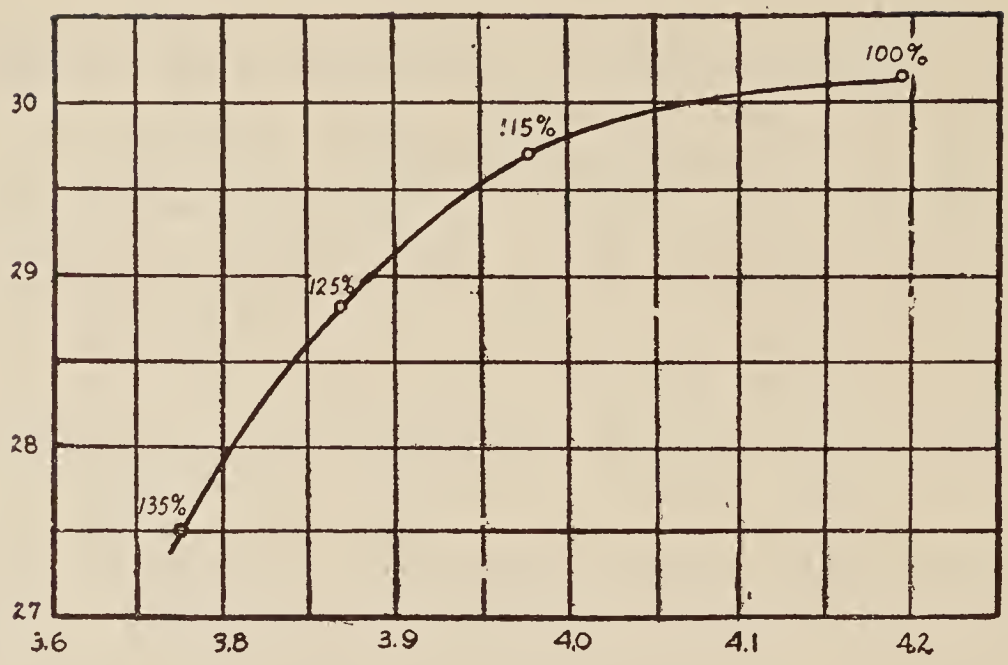
Carbon burnt with the requisite quantity of oxygen	.. 3540°T
,, ,, ,, ,, of air	.. 2320°T
,, ,, 10% excess of air, the whole of the air being preheated to 1000°C	.. 2684°T
,, ,, with 50% excess of air preheated to 1000°C	.. 2465°T
Hydrocarbon (C=84% ; H=14%, Residues=2% burnt) with requisite quantity of air preheated to 1000°C	.. 2760°T
Producer gas (H_2=8% ; CH_4=4% ; CO=18·0% ; N_2=60·0%) with requisite quantity of air, both air and gas preheated to 1000°C.	2350°T

The values so obtained are in close agreement with those obtained experimentally by some of the workers, and reveal the effect of preheating and excess of secondary air very strikingly. The great demand for gasoline is an advantage to the industrial plant owner, as owing to this, oil fuel is both cheaper and safer. It is important, however, to note here that ordinarily it is only in countries where oil and coal occur simultaneously, that for purposes of burning and raising steam,

their competition is within the range of practical economics. There the American Engineers' approximate rule—"Divide the cost of coal in dollars per long ton (2,240 pound) by 2; if the result is greater than the cost of oil in cents per gallon, it will pay to burn oil"—is sound. But the experienced technical chemist will not stop at that. The decidedly higher temperature of a hydrocarbon flame than that of producer gas, would, according to emission law, diminish the "heat periods," and as a matter of fact, throughout a continuous run of 53 days, the experimental oil fired glass furnace of $\frac{1}{2}$ ton capacity in the author's workshop showed a reduction of heat periods to the extent of approximately 33 per cent. when compared with producer gas firing. It is doubtful, however, whether the fourth power law, generally true of radiation from solid bodies, is equally true of flames. A contribution of great significance by Haslam, Lovell and Hunneman (Journal of Industrial and Engineering Chemistry, 1925, March, page 272) reveals certain important facts in this connection. They found that the amount of radiation in all cases decreases somewhat as the aeration is increased over the theoretical value. This decrease, however, is according to their experimental findings, not due to decrease in the flame temperature; one would infer therefrom that the flame followed a modified form of the black body radiation laws. If the flame had obeyed the fourth power law, the curve of radiation against the fourth power of the absolute temperature would be a straight line. The actual line shows a pronounced curvature and "distinctly proves that the fourth power law is not applicable in this form."



Looking at radiation as due to simple vibration of molecules, and assuming according to the kinetic theory of gases that this vibration is proportional to the square root of the absolute temperature, a curve of the square root of the calculated absolute flame temperature against the radiation would be a straight line. As a matter of fact the actual line has a pronounced curvature.



More significant from the technical point of view, however, is the important observation by these investigators that the flame above a certain depth becomes opaque to its own radiation, the critical depth being about 100 cm. There must then be a certain amount of absorption of radiation by the flame itself, and a translation of this energy into other forms. It is difficult to imagine how radiation due only to temperature might be so changed. Still more irreconcilable is the relation between radiation and flame temperatures of different gases. The following table from Haslam, Lovell, and Hunneman's work indicates this point strikingly :—

Gas.	P.c. of theoretical air.	Kg. cals. per grm. mol. of gas.	Radiated per grm. mol. of flue gas.	P.c. of latent heat radiated.	Calculated temp.
CH_4 ..	100	30·3	3·06	14·9	1770°
Illuminating ..	100	15·7	2·56	13·8	1850°
Carbon monoxide ..	100	6·8	2·06	10·4	1700°

The value of radiation for illuminating gas which has a very high flame temperature, is midway between the radiation values for methane and carbon monoxide, which have lower flame temperatures. These facts would indicate that there is no simple relation between flame temperature as calculated and the amount of radiation.

Another fact which puts the temperature factor somewhat more to the background is the decrease in radiation when the primary air is preheated. If one may assume that a fore-combustion might be initiated due to preheating of primary air, then the radiation, being representative of a part of the combustion, should indeed be low. On the whole, to attempt to compare radiation and chemical reactions is entirely reasonable, but to determine the chemical reactions by means of the end products is another matter. It would seem, however, specially in view of the very great advance made in the study

of spectra, that in the measurement of the distribution of energy in the spectrum of flames there would probably be found a means of investigating chemical reactions.

Methods for the utilisation of the current solar energy.—I shall now conclude with a brief reference to this important aspect of power problem. The rich vegetation of the tropics, the starches and celluloses thereof, have long been the objective of chemists for conversion into power fuel. In countries remote from the channels of trade, the value of the molasses is very low and the price of gasoline high. In consequence, the production of alcohol fuel is a profitable venture there. With different prices for molasses, alcohol gallon has been priced differently; but on an average in all sugar-producing countries a gallon of 95 per cent. alcohol may be fixed at 6 to 8*d.* Economic considerations would require alcohol to be utilised first in tropical and sub-tropical countries. Ross and Ormandy report that "the first really large-scale experiment on these lines is being carried out in Queensland, Australia, where a plant for the production of 2 million gallons of fuel per annum is now being erected, and necessary steps are being taken for the erection of three further plants. The raw materials to be employed in these plants are molasses from the sugar plantations and starchy products such as Cassava or sweet potato to be grown as alternative "cleaning" crops in rotation with the sugar-cane." Modern chemical work in alcohol production may be broadly divided into fermentation and synthetic production. The latter being dependent upon coal, is left out of consideration. Under the first head comes the conversion of wood and straw celluloses into fermentable sugars. Whilst the prospect of wood-alcohol industry is still uncertain, and that of sulphite liquor alcohol is no less so owing to the very limited supply of the latter, the problem of alcohol from rice straw, inspite of failures in the past, should receive fresh impetus from the publication of a work on the subject by N. Taketomi only a few months ago in the Journal of the Society of Chemical Industry, Japan, 1926, 29, 43–47. He maintains that rice straw when heated with 1 per cent. sulphuric acid at about 134 deg. C for 30 minutes in an autoclave, yields 15 per cent. of sugar on the dry matter used, and gives 5·4 per cent. of alcohol, race XII distillery yeast being used in these experiments. One is disposed to view this announcement with a certain amount of reserve, as the speaker himself after long trials never secured fermentation beyond $1\frac{1}{2}$ per cent. although the reducing sugar content after digestion, was as high as 19 per cent., and the pulp remained suitable for cheap paper. An authentic report on the same subject from the experimental plant of the Burmah Oil Company, supplied to me by my friend Mr. B. N. Banerjee of the Indian Institute of Science, Bangalore, gives, however, an entirely different

prospect of alcohol manufacture from rice straw. Indeed, by successive digestion of the straw with 4 times the weight of 1 per cent. sulphuric acid solution, sugar to the extent of 15 to 25 per cent. has been obtained yielding alcohol as high as 8 per cent. on the straw, though the residual pulp is valueless for ordinary purposes. The probability of utilising the latter for power gas generation by fermenting with Omeliansky's bacteria, should not, however, be lost sight of, as 25 per cent. of the produced gas appears to have been found to be combustible. The whole question of power alcohol from rice straw, therefore, needs critical re-examination in the light of the various facts mentioned above.

Gentlemen, I cannot conclude without a passing reference to the petroleum and the coal reserves of the world, if only to explain the real extent of the danger of the so-called fuel shortage. Theoretically speaking, the shortage of the fuel is inevitable, if fresh deposits are not discovered to keep pace with our annual consumptions. There are, no doubt, discoveries being made from time to time as well as systematic endeavours to utilise the current energy of the Sun which in the tropics gives rise to such enormous quantities of fuel products. The conversion of these vegetable products into alcohol is not, however, the only way in which attempts have been made to ward off the immediate danger of the fuel shortage. The vegetable oils such as palm oil, olive oil, castor oil, etc., have also been tried in certain countries with the object of using them in internal combustion engines. In the Belgian Congo where a kilogram of palm oil has been quoted at anything between 8 centimes and 40 centimes, successful tests with a 2-cyclic semi-Diesel Motor of Swedish manufacture developing 10 H.P. at 500 revolutions per minute, have been performed. The calorific value of palm oil is about 16,000 B.T.U. which is about 25 per cent. less than that of crude oil, but in those localities where the low price of the vegetable oil makes up for this difference, there is a growing conviction that these can be successfully used. As is obvious, this feature of internal combustion engines has special reference to our Indian conditions where in some places very cheap vegetable oils are available or producible. Mention should be made of the castor plant which may be regarded as a prolific weed in nearly all tropical regions, and of the extensive application which castor oil has lately been receiving in connection with aeroplane lubrications. Soyabean oil and cocoanut oil have also been tried, but in all cases where the oil is edible, their use is restricted by the demand for human consumption. It would appear, therefore, that these oils would form at any rate, substitutes for heavy oils if a real shortage did occur.

As I have already indicated, the problem before us is not entirely one of finding fuels from the current solar energy,

but also one of economic fuel utilisation, to check the possible rise in price, if not to postpone the anticipated shortage. The following table showing the coal resources of India and other countries will be instructive from this point of view :—

Italy ..	..	..	243	Million	Metric Tons.
Portugal ..	..	..	20	,,	,, ,,
Spain ..	..	..	6220	,,	,, ,,
Belgium ..	..	..	11000	,,	,, ,,
India ..	..	..	70000	,,	,, ,,
Japan ..	..	..	7971	,,	,, ,,
Great Britain	..	..	140000	,,	,, ,,
France ..	..	..	4500	,,	,, ,,
Germany ..	..	..	94865	,,	,, ,,
United States	..	..	3200000	,,	,, ,,

Turning now our attention to petroleum, whilst economic utilisation and handling are equally essential, there is a remedy which consists in more efficient and careful exploitation of the already detected oil horizons. On an average the proportion of the total quantity of oil underground that can be brought to the surface, is not more than half. Indeed it has been variously estimated at from only 10 to 50 per cent. When pumping no longer pays, we pull up our pipes one after the other and abandon the field with at least half the oil left in it. This is due to the fact that oil does not lie in underground caverns or lakes but in porous sands or lime-stones in which flow is restricted by the viscosity of the oil, by the separation of solid wax or paraffin in the pores of the rock and by the local imperviousness of the oil-bearing rock itself. A very important innovation in this direction to obtain more oil from the wells has been the use of vacuum pumping, of carefully controlled water-flooding and of compressed air. A significant experiment in this direction was performed by the Germans in 1916 who, rendered helpless by the want of motive fuel, resolved to go down and, so to say, fetch the oil; they sank shafts, drove galleries and mined the oil-sand. At Pechelbronn in Alsace, M. Paul de Chambrier of the Deutsche Petroleum Aktiengesellschaft was able to gain two and half times more oil than had already been obtained by boring. From one ton of bituminous sand at Pechelbronn there were obtained—

By boring 20 kgs. or 16·67 per cent.,

By oozing into shafts and galleries, 52 kgs. or 43·33 per cent., whilst 40 per cent. still remained in the pores of the sand, and could be extracted by washing with hot water. Thus, five times more oil can be made available by this method than by ordinary boring of holes. In three and half years the galleries at Pechelbronn produced 51,080 tons of oil "oozings." The results speak for themselves and indicate a most re-assuring aspect of the future shortage of petroleum.

Gentlemen, from what I have said above, I hope it is clear that the fuel problem, the greatest of world's problems, has

to be fought by Chemists and Engineers in co-operation. In fact, this combination is to be noticed in most undertakings of to-day. In proportion as these two sciences combine, the utility of science as a whole will undoubtedly improve. May I, therefore, enter a plea for a greater activation of our chemical studies and research from a practical point of view. As a result of intimate contact with universities and manufactories both at home and abroad for the last fifteen years, I am firmly convinced that the mighty power of scientific education, and indeed, of education in general, if consciously organised and regulated with an eye towards its application would lead to an era of human happiness, free from disease and poverty which might appear to be only a dream to-day.

The study of the natural sciences though fairly rich in traditions by now, has received impetus only lately in India through the efforts of some distinguished personalities as also of the State. The appreciation of its importance in European and American countries has attained such proportions that the pursuit of science has now emerged out of the merely specialised course for the few to the state of an ordinary cultural necessity for the masses in general. Several factors have contributed to this. Though it must be conceded that in the beginning, the power of science had been sought for personal gain as is shown unmistakably in the majority of the efforts of alchemists, yet as man evolved, the idea of social service was no longer dissociable from the study of science. Once we admit this, it is clear how science has now come to be regarded as an indispensable element in our cultural existence. If it is true of the humanistic cultures that they confer upon man certain ascendency over physical conditions, there can be no doubt that a combination of these with the realistic knowledge of the natural forces, would ultimately lead us to the total mastery of Nature! An age of human sufficiency will then ensue which marks to-day the goal of our aspirations. The ceaseless effort of Nature to reclaim her dominion has virtually placed man in the position either of a martyr or of an antagonist. As the sailor who meets with breakers must either grapple with them to reach the shores, or be content to go under with his craft, so is it with the human species, the very continuance of which is secured by fight with the visible and the invisible. The object of our so-called material science is thus bound up with issues of the most profound significance—the continuity of the species itself. The place of such a science till lately designated by the half spiteful adjunct 'material' is thus no longer uncertain in human economics, but like the stream which gradually widening into the river ultimately merges into the sea, science is merging into the total scheme of our existence. It is not surprising, therefore, that the pursuit of science is free from most of the sectarian notions often inseparable from other

activities of man. Team work, the note struck by the General President of our Congress last year at Bombay—is not only feasible but inevitable in this noble work. Its immediate scope, though sometimes apparently national, is thus really international.

If we look round to find the use of chemical science in the general disposition of our life, we shall have no hesitation in concluding that whether in civilised or in comparatively crude state of human society, this science exerted its influence in almost all departments of our needs. And no wonder, as most changes in the physical world are more or less attended with what is known as chemical change. The jurisdiction of chemical science, therefore, is inordinately vast, and thus to-day its scope extends from the mammoth rock down to subatomic phenomena! If in the past the study of chemistry was considered synonymous with the mixing of one ingredient with another, on the off chance of stumbling against some change, so much conscious work has been brought within its range to-day that the Science of Chemistry has outstripped most others in precision and the consequent 'discipline' of its votaries. Thus a chemist, to be a successful one, must to-day have a sound education in mathematics, physics, botany, geology, physiology and indeed, in most branches of existing knowledge. Modern chemistry is, therefore, one of the most difficult of sciences, and as such the organisation of its study is becoming increasingly difficult. To my mind study and research in Chemistry—not in the restricted sense in which we are apt often to view the science in this country, but in the broader aspect of its practical development and application to the supreme service of Humanity, some of which I have attempted to indicate, however imperfectly, in my discourse to-day is national work, and as such its cause should be furthered by the State and the Country at any cost. Countless changes notwithstanding, 'Knowledge still is Power.'

Abstracts of Papers.

1. A preliminary note on the ignition points of sulphur and phosphorus.

N. M. Shah *and* R. L. Alimchandani, Dharwar.

Sulphur when washed with ammonia ignites at 355°C in an atmosphere of oxygen, while the ignition point of unwashed sulphur is 282°C.

Red phosphorus, on the other hand, when treated similarly ignites at a lower temperature than the phosphorus which is not washed with ammonia.

In case of red phosphorus, the absorption of oxygen precedes the ignition, while no such phenomenon was observed in case of sulphur.

Further, the glow of yellow phosphorus is also affected by similar treatment with ammonia.

The work is being continued.

2. Compounds of hydrazine with metallic sulphites and nitrites.

P. R. Rây *and* B. K. Goswami, Calcutta.

By the action of hydrazine hydrate upon solutions of metallic sulphites in aqueous sulphurous acid under different conditions a number of compounds have been obtained. Zinc, manganese, nickel, cobalt and cadmium sulphites gave a number of well-defined hydrazine compounds and double hydrazine sulphites of the following composition :—

$$xMSO_3,\ yN_2H_4,\ zH_2O$$

$$\text{and } MSO_3,\ (N_2H_4)_q,\ H_2SO_3,\ zH_2O.$$

where M=Zn, Mn, Ni, Co or Cd;

x, y and z are integers;

q=1 or 2; z may be also equal to zero.

Of these the compound $NiSO_3,\ 3N_2H_4$ deserves special mention, as it affords an instance of a stable six-fold co-ordination compound of nickel.

Sulphites of barium, strontium and calcium fail to combine with hydrazine. Solution of uranyl sulphite in aqueous sulphurous acid gave products of indefinite composition.

By the action of dilute hydrazine hydrate on well-cooled solutions of acetates of certain bivalent metals in presence of sodium nitrite, a number of hydrazine addition-compounds of bivalent metallic nitrites has been obtained. Their composition is represented by :

$$xM(NO_2)_2,\ yN_2H_4 \quad \text{where M=Cd, Ni or Co;}$$

x=1 or 2, and y=2 or 3.

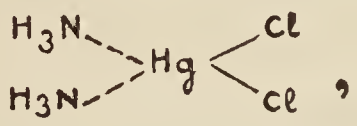
3. The constitution of infusible and fusible white precipitates of mercury.

P. R. Rây *and* P. C. Banerjee, Calcutta.

From a study of the action of ethyl mercaptan, thiourea, thiocarbanilide and hydrogen peroxide upon the fusible and infusible white

precipitates of mercury certain conclusions regarding their constitution have been arrived at. The ethyl mercaptan gives mercury mercaptide, mercury chloromercaptide, ammonia and ammonium chloride. Thiourea leads to the formation of mercuric sulphide, mercuric chloride, cyanamide, ammonia and ammonium chloride. With thio-carbanilide, a reaction already studied by previous workers, mercuric sulphide and diphenyl-guanidine hydrochloride are obtained. Hydrogen peroxide reduces them to metallic mercury slowly in a neutral medium but readily in presence of ammonia. The infusible white precipitate is therefore regarded as an equilibrium mixture of :

The fusible white precipitate, which is formed by the action of ammonium chloride upon the infusible precipitate is represented for that reason as having the structure usually adopted



which readily changes into infusible white precipitate and ammonium chloride under the influence of external circumstances.

4. A new series of double sulphates of the copper magnesium group and the sulphonium bases.

Prafulla Chandra Rây *and* Nirmalendu Nath Ray, Calcutta.

Double sulphates of triethyl sulphonium sulphate and the vitriolic sulphates have been obtained. These are found to possess the general formula

$$MSO_4\ (Et_3S)_2SO_4 + 10H_2O,$$

where M=Fe, Zn, Ni, Co, Cd. Magnesium sulphate as well as manganese sulphate, however, yielded double salts of the composition

$$2M'SO_4(Et_3S)_2SO_4 + 11H_2O$$

where M′=Mn, or Mg. Nickel sulphate and trimethyl sulphonium sulphate formed a similar double salt. The double sulphates are hygroscopic and crystallise in needles. On adding alcohol to an aqueous solution of the salts, the inorganic components are precipitated.

5. The action of a solution of bromine in carbon tetrachloride on strontium hydroxide octahydrate.

Kishen Lal, Harnam Das *and* H. B. Dunnicliff, Lahore.

1. The first action which takes place results on the formation of equimolecular quantities of $SrBr_2$ and $Sr(OBr)_2$.

2. This reaction is followed by other slow reactions and the final product contains varying proportion of strontium bromide and bromate.

The unstable strontium hypobromite probably decomposes in one of the two ways :

$$3Sr(OBr)_2 = 2SrBr_2 + Sr(BrO_3)_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$
$$Sr(OBr)_2 = SrBr_2 + O_2$$

followed by direct oxidation

$$Sr(OBr)_2 + 2O_2 = Sr(BrO_3)_2 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The amount of each change depends on concentration, temperature and light, etc.

6 The determination of the equivalent weights of mercury, magnesium, tin and aluminium by the synthesis of their bromides.

Bhan Singh *and* H. B. Dunnicliff, Lahore

Five methods of estimating the equivalent weight of mercury, magnesium, zinc, aluminium and tin have been investigated. Of these, four involve the preparation of the anhydrous bromides of the metals. The experimental results are discussed.

7. The action of alkaline ferricyanide on silver nitrate solution and the constitution of silver peroxide.

P. N. Dasgupta *and* P. R. Rây, Calcutta.

By the action of alkaline ferricyanide upon a solution of silver nitrate in the cold (0°C), a black precipitate had been obtained which on analysis was found to be a mixture of a higher oxide of silver, silver ferrocyanide and silver ferricyanide. From an estimation of the amount of available oxygen, the total quantity of iron in the product, a knowledge of the total amount of silver and then making allowance for the amount of available oxygen due to the ferricyanide, the constitution of the silver peroxide has been proved to be represented by the formula Ag_2O_2. The product was found to be free from any silver monoxide and it decomposed rapidly on keeping into a mixture of ferro- and ferri-cyanide of silver.

8. Varying valency of gold. Part II. Inadequacy of Werner's theory.

Prafulla Chandra Rây *and* Kshitish Chandra Bose-Rây, Calcutta.

In continuation of the study of the varying valency of gold the authors subjected the complex compounds obtained by the action of gold chloride on organic sulphides (J. Ind. Chem. Soc., 1924, *1*, 63) to treatment with ammonia and organic bases. The sulphide group was wholly or partially replaced by the basic radicles and the products formed are of the type, $AuCl_n.mB$ (where n,m-numerals, B-base). The configuration of these complex salts can in most cases be taken as representations of Werner's type. In some cases, however, Werner's theory bas been found to be quite inadequate to assign any configuration to the compounds obtained.

9. Varying valency of platinum. Part V. The inadequacy of Werner's theory to explain certain anomalous cases.

Prafulla Chandra Rây *and* Kshitish Chandra Bose-Rây, Calcutta.

In continuation of Part IV (recently communicated to J. Ind. Chem. Soc.) the authors have obtained a variety of products by subjecting the complex compounds obtained from platinic chloride and

organic sulphides to the action of organic bases. They generally conform to the type $Pt_n\ Cl_m$. B_p (where n, m, p,—numerals; B-base.) In some remarkable cases the configuration of these complex salts could not be brought within the perview of Werner's theory and the astonishingly increasing number of these cases leave the authors searching for a suitable explanation for the inadequacy of the theory.

10. Action of rubeanic acid upon sodium cobaltinitrite and the formation of a cobaltic rubeanate.

P. R. Rây *and* A. K Chattopadhya, Calcutta.

By the addition of an alcoholic solution of rubeanic acid to an aqueous solution of freshly recrystallized sodium cobaltinitrite in presence of a considerable amount of sodium acetate a dark brown powder was obtained. The composition corresponds to the formula—Co_2(NH. CS. CS.NH)$_3$, $6H_2O$. Evidences in support of its constitution are also adduced.

11. Action of hexamethylene tetramine upon solutions of salts of the elements of Group III and a new method for the quantitative separation of iron from manganese, zinc, nickel and cobalt.

P. R. Rây *and* A. K. Chattopadhya, Calcutta.

Hexamethylene tetramine, which is hydrolysed in acid medium into formaldehyde and ammonia according to the following scheme:

$$(CH_2)_6N_4 + 6H_2O = 6CH_2O + 4NH_3$$

has been successfully employed for the quantitative separation of iron from manganese, zinc, nickel and cobalt. Acids liberated by the hydrolytic decomposition of ferric salts induce hydrolysis of hexamine leading to the formation of ammonia, the latter at once combining with the acid, progressively and completely precipitates the ferric hydroxide. Manganese, zinc, nickel and cobalt are also partially precipitated as their hydroxides only from boiling solutions of their salts. This is completely inhibited by the addition of a little ammonium chloride to the solution before separation. The results obtained are excellent and can be favourably compared with those of the basic acetate and the barium carbonate methods. The process is also free from the tedium that attaches to the latter two methods.

The process, however, fails when applied to the separation of chromium from manganese, zinc, nickel and cobalt and the subject is still under investigation.

12. A note on the determination of mixture of thiosulphates and sulphites.

Chaman Lal Soni *and* H. B. Dunnicliff, Lahore.

Mixtures of the sodium salts of these two acids of about decinormal strength can be estimated by (1) adding the solution drop by drop to a N/20 solution of iodine, acidified to about N/50 strength with hydrochloric acid until the colour of starch indicator (about 0·005%) is bleached. The solution has to be added slowly and with intermittent swirling. The acid formed by the action of iodine on sodium sulphite is estimated by back titration.

13. The titration of acids by a solution of sodium hydrogen phosphate.

N. M. Shah *and* R. L. Alimchandani, Dharwar.

The authors have replaced the sodium borate solution, used in the experiments of Meldrum and Thakore (Abstracts, Indian Science Congress, Lucknow, 1923) and of Meldrum and Mehta, by a solution of sodium hydrogen phosphate.

The authors find that the volume of sodium hydrogen phosphate solution required for a given amount of an acid lessens as the temperature rises and that when the volume is plotted against temperature the graph is a straight line.

14. The titration of acids by a solution of sodium borate.

A. N. Meldrum *and* S. M. Mehta, Bombay.

In continuation of work, by Meldrum and Thakore, on the titration of weak acids (sugars and polyhydric alcohols) by sodium borate solution, the authors have examined the behaviour of stronger acids, such as oxalic, sulphuric and hydrochloric acid.

It is found, as before, that the volume of sodium borate solution required for a given amount of an acid lessens as the temperature rises, and that when volume is plotted against temperature the graph is a straight line.

15. Estimation of halides in a mixture.

Q. A. Mansuri, Aligarh.

When suspended in an ammonical solution, silver halides are completely converted into silver sulphide which readily changes to silver nitrate by the action of nitric acid. By the gravimetric or volumetric estimation of silver the halides in a mixture could be easily determined.

16. Complex salts derived from *p*-nitrosodimethyl aniline and metallic chlorides.

Indubhusan Sengupta.

Chlorides of Cu, Zn, Hg, Ca, Ag, Ni, and Co react with *p*-nitrosodimethyl aniline or its hydrochloride in alcoholic solution forming deep coloured crystalline substances soluble in water. Dilute alkali or H_2S does not precipitate the hydroxide or the sulphide of the metals. The halogen atoms are in some cases non-ionisable while in others they are partially or completely ionisable. The complex salts are of the type $MeCl_m$ $[NO.C_6H_4N(CH_3)_2]_n$ where Me=Cu, Zn, Hg, Ca, Ni, Co or Ag ; m=1, 2 or 3; n=1 or 2.

Dimethyl aniline reacts with these compounds in dry absolute alcohol forming compounds of the type $MeCl_m$ $[NO . C_6H_4 . N(CH_3)_2]$ $[2C_6H_5 . N(CH_3)_2]$. These dissolve in water yielding deep violet solution.

17. Action of hydrogen sulphide on lead peroxide.

G. Sambamurti, Madras.

Hydrogen sulphide passed over lead peroxide produces a blaze at once. The vigour of the reaction decreases with pressure until the latter falls to 130 mm., when the peroxide turns red and becomes "passive." Either increase of pressure or of temperature cannot restore the activity of the peroxide once turned passive. In the presence of impurities passivity is not brought about even on reducing the pressure to 6 mm.

18. Catalytic oxidation of water.

M. Goswami, Calcutta.

Experiments have been made to oxidise water catalytically to hydrogen peroxide by the intervention of various catalysers. Steam was passed in conjunction with air mixed with pure carbon dioxide over a catalyst prepared in *situ* in a galvanised iron tube at 300°. The ensuing gas was condensed in a copper spiral immersed in ice and the liquid thus obtained was found on examination to contain a slight quantity of hydrogen peroxide as evidenced by the liberation of iodine on a starch-iodide paper. Control operations were done without steam and the results showed definitely that water was catalytically oxidised.

Further experiments are in progress, and the process will shortly be the subject of a patent for which application has been made.

19. Smith-Stoner's classification of electron subgroups and the co-valency conception as applied to simple and co-ordination compounds.

P. R. Rây, Calcutta.

Assuming the correctness of Smith-Stoner's classification of electron sub-groups it has been shown that sharing of an electron pair for each chemical bond fails to explain the behaviour of simple compounds like CH_3Cl, $CHCl_3$, CH_2Cl_2, NH_2OH, etc., as also the phenomenon of isomerism in the metal-ammonium compounds. The assumption of one electron bond is shown to remove these difficulties to a great extent. Co-valency conception is undoubtedly of great value in explaining the formation of elementary molecules, whereas in the case of compounds like CH_3Cl or $CHCl_3$ it demands the existence of more than one type of molecules in which the energy content of individual atoms would differ due to sharing of electrons from different orbital groups. The same holds good in the case of co-ordination compounds as well. Electron grouping in a number of co-ordination compounds of cobalt, chromium and nickel has also been represented.

20. The system $(NH_4)_2SO_4 - H_2SO_4 - C_2H_5OH$.

H. B. Dunnicliff, A. L. Aggarwal *and* R. C. Hoon, Lahore.

This system has been examined at 18°C

(*a*) by the action of alcohol on ammonium hydrogen sulphate,

(*b*) by the action of alcoholic sulphuric acid on ammonium hydrogen sulphate.

The following compounds are formed and the concentrations between which they exist have been determined :—

(1) $3(NH_4)_2SO_4 \cdot H_2SO_4$ or $(NH_4)_3H(SO_4)_2$

i.e. triammonium hydrogen disulphate.

(2) $(NH_4)_2SO_4 \cdot H_2SO_4$ or NH_4HSO_4

i.e. ammonium hydrogen sulphate.

The phase corresponding with the composition $3(NH_4)_2SO_4 \cdot 2H_2SO_4$ is indicated but it is not certain if it is a chemical individual or a mixture

21. Activity of cadmium sulphide in presence of neutral chlorides.

S. KRISHNAMURTI, Chidambaram.

The effects of a number of chlorides on the precipitation of cadmium sulphide in acid solution are studied from the point of view of activities of ions. It is shown that the activity of cadmium sulphide decreases with the addition of a neutral chloride in a certain order. From theoretical consideration it is predicted that the ratio

$$\frac{(\text{activity of hydrogen ion})^2}{\text{activity of cadmium ion}}$$

should increase with the addition of a neutral chloride. This is verified by certain E.M.F. measurements and the increase explained from the ionic point of view.

22. The indices of refraction of some organic crystals and of inorganic salts in aqueous solution.

S. S. BHATNAGAR, Lahore, *and* S. L. BHATIA, Bombay.

This is a brief study of the refractive indices of some organic crystals, and of inorganic salts in aqueous solution. The organic substances have been studied both in the crystalline form as well as in solution. The crystals used were those of phenyl acetic acid, oxalic acid, tartaric acid, citric acid, thymol and borneol. These were examined by reflection in artificial white light, and in sodium light, by the help of Abbe's refractometer with unjacketed prisms model No. 11. It has been found that the values for the refractive indices for tartaric acid and citric acid are a little higher than those determined by J. H. Gladstone and W. Hibbert (J.C.S., 823–833, 1897) who have studied the crystals by Dufet's method.

In the second part of this paper some useful data have also been determined for the molecular refractivity differences between the persulphate and sulphate, between the chlorate and chloride, between the bromate and bromide, and also between iodate and iodide radicals. The results show that the molecular refractivity difference for bivalent cations is double that for monovalent.

23. The relation between atomic structure of salts and the physical properties of their solutions.—Part I: Viscosity and surface tension.

RANGO KRISHNA ASUNDI, Bombay.

(1) It is shown that at a temperature of 50°C and 5V dilution, the product, length of unit cube of salt × coefficient of viscosity, is a constant, for aqueous solutions of NaCl, NaBr, NaI, KCl, KBr, KI, NH_4Cl, NH_4Br, and NH_4I.

(2) At a lower dilution, viz. 4V, the product is not the same for all these salts but it is constant for all salts of the same metallic radical.

(3) At a lower temperature, viz. 30°C, the product varies with the metallic radical as in (2).

(4) Data for surface tension of aq. solutions of these salts are available at 18°C and 8V dilution. The product, length of atomic cube × surface tension, is not constant but is of the type shown in (2) and (3).

(5) It appears that at a higher temperature, viz. about 50°C, the values of surface tension will be such as to give a constant for the product, length of atomic cube × surface tension.

Further experiments are in progress.

24. On the application of kinetic theory to surface films.

K. C. Sen, Allahabad.

In this paper the writer has studied the formation of dimethyl aniline films in benzene-water and heptane-water interfaces in relation to an equation of state proposed recently by Schofield and Rideal, $F(A \times B)=xRT$ where B is the limiting molar volume under high compression and $1/x$ measures the lateral cohesion of the molecules. The results show that for relatively weak solutions, so long as the film remains unimolecular, the equation is obeyed by surface films. The films formed at interfaces may not always be unimolecular, but may be several molecules deep. So long as weak solutions are employed, and the films remain unimolecular, the effect on the surface tension is due to their thermal agitation alone. Under these conditions Schofield and Rideal's conclusion that at a given temperature, their effectiveness depends solely on their surface concentration, their interfacial areas and their lateral cohesion seems to be correct.

25. Experimental contribution to the theory of equation of state for adsorbed substances.

H. L. Roy, Calcutta.

Surface tension of solutions of highly capillaractive substances has been measured at different concentrations according to the bubble-pressure method with the help of an apparatus so modified as to give more accurate readings than those hithertofore obtained. A new equation has been derived from Gibb's well-known thermodynamic equation relating surface-tension of solutions and Volmer's equation of state for adsorbed substances (Zeitschr. f. physikal Chemie, p. 250, 1925). From the measurement of surface tension of solutions by previous workers and those by the author himself, it is proved that Volmer's equation holds good up to middle concentrations. Area occupied by a molecule of the adsorbed substance on the surface is calculated and new evidence in support of Langmuir's theory of oriented molecules in the surface has been obtained. It is also found that adsorption-potential of a capillaractive homologous series of fatty acids increases in arithmetic progression and thus obeys Traube's law. It is also found that the area occupied by a molecule in the surface and the adsorption-potential of a substance is independent of concentration.

26. Effect of impurities on the intensity and colour of phosphorescence of calcium sulphide.

S. S. Bhatnagar, N. A. Yajnik *and* Narain Singh, Lahore.

In the present investigation the effect produced on the phosphorescence of calcium sulphide by the addition of nitrates of copper, lead, cadmium, barium and strontium, the sulphates of copper and cadmium and the chlorides of lead, barium and strontium, and some fluorescent substances such as fluorescein, eosin, methylene blue, quinine hydrochloride, as impurities has been studied. It was found that—

(1) for every impurity there is an optimum concentration which produces a maximum increase in the intensity of luminescence;
(2) increase beyond this optimum makes the luminiscence feebler and redder;
(3) the fluorescent substances tried can be arranged in this order according to their effect on the luminiscence:
Quinine hydrochloride—Eosin—Methylene blue—Fluorescein;
(4) with age luminiscence becomes feebler and redder

27. Surface reflectivity of liquids

S. S. Bhatnagar, N. A. Yajnik *and* N. G. Mitra, Lahore.

The relation between the energy in the reflected rays form various liquid surfaces and the surface orientations was studied. The liquids used were some organic acids and alcohols, some colloidal sols and solutions of inorganic substances. As the result of the investigation, it was found that:—

1. The reflectivity of acids is decidedly different from that in case of water but in the case of solutions of inorganic salts there is no appreciable difference.
2. The reflectivity of methyl alcohol is greater than that of water and it goes on increasing in case of alcohols, as we go higher up the series. The reflectivity in case of primary and *iso*-alcohols showed no difference thereby showing that the surface structure of the primary and *iso*-compounds remains the same although there is a difference in configuration.
3. The reflectivity from the surfaces of the sols was found to be the same as that from the surface of water.

28. Some observations on the factors governing the hygroscopicity of aqueous crystals.

S. S. Bhatnagar, N. A. Yajnik *and* Prakash Chandra, Lahore.

The present investigation was undertaken to see if the hygroscopicity of aqueous crystals and the isotopic nature of the radicles constituting the crystals were somehow or other correlated. The following conclusions were arrived at:—

1. When both the constituent ions are of isotopic elements, the salt is necessarily hygroscopic.
2. If one of the constituent ions belongs to an isotopic element, whilst the other one belongs to non-isotopic one, the salt may or may not be hygroscopic.
3. When both of the constituents are non-isotopic, the salts are not hygroscopic.

29. Theories of the formation of periodic precipitates: II.

A. C. Chatterji, Lucknow.

1. The basic idea of the theory advanced here is that Liesegang rings are formed by the coagulation of the peptised sol and that the coagulated mass in the course of its formation and when precipitated adsorbs and coagulates completely or partially the sol of the same substance from the neighbouring layers.
2. The view advanced here is able to explain the formation of two distinct classes of Liesegang rings. The first class consists of rings separated by clear spaces. The second class of rings is made up of alternate layers of coagulated mass and the sol of the same substance usually having different colours.
3. The nature of the gel has a direct influence on ring formation and it does not play the part of an indifferent medium only. In the beginning t exerts a peptising influence on the sparingly soluble substance, the ring being produced later on by the coagulation of the peptised sol.

30. On the formation of periodic precipitates : V.

A. C. Chatterji, Lucknow.

In previous papers (Proceedings Indian Science Congress, 1925, 1926) it has been suggested that under convenient conditions and in suitable gels all sparingly soluble substances are capable of forming Liesegang rings. Experiments on ring formation of various sparingly soluble substances have been carried out in different gels which further support the above view.

Also rings of many substances which were known have been obtained in other gels in which they were not tried before.

Generally it has been found that by decreasing the concentration of the diffusing electrolyte, the distance between two consecutive rings becomes greater.

It has been found that the effect of change in the concentration of any of the reacting electrolytes does not depend on its relative position as to whether it is being diffused from the top or is distributed uniformly in the gel, but on its power to coagulate a sol of the respective sparingly soluble substance peptised by the gel.

More rings are formed in light than in the dark.

Anomalous rings consisting of spirals have been obtained with manganese sulphide in agar, lead iodide in agar, lead iodate in gelatine, both in light and in the dark.

Light does not play a very important part in the production of anomalous rings of spiral nature as they are produced both in the dark as well as in light.

The spiral rings are caused by more rapid dehydration under favourable conditions, and consequent coagulation and crystallisation of certain parts of the rings, which are in the beginning certainly of a gelatinous nature, in preference to the other parts.

31. Peptising influence of gels on sparingly soluble substances and its importance in the formation of Liesegang rings.

A. C. Chatterji, Lucknow.

1. The peptising influence of gelatine, agar-agar, and starch on various substances in course of their formation has been studied.

2. The amount of a sparingly soluble substance that can remain suspended in gelatine, agar-agar, and starch is exceedingly larger than the solubility of the substance in water.

3. If a certain protective colloid exerts a very powerful peptising influence on a sparingly soluble substance and a peptised sol of the same substance cannot be coagulated by either of the reacting electrolytes used in the formation of the sparingly soluble precipitate, Liesegang rings should not be obtained with that sparingly soluble substance in that medium.

4. If the protective colloid exert a poor peptising influence on sparingly soluble substances, such substances should not form Liesegang rings in that particular medium.

5. The formation of Liesegang rings of sparingly soluble substances would be favourable in those gels which exert only a medium peptising influence on them.

32. Adsorption of colloidal solutions and of ions by freshly prepared precipitates. II.

A. C. Chatterji, Lucknow.

Experimental results on the adsorption of sols of (1) ferric hydroxide (2) silver chromate, (3) lead chromate and (4) arsenious sulphide by their respective freshly obtained precipitates show that the above sols are highly adsorbed. These substances give Liesegang rings of the first type in which two consecutive rings are separated by clear spaces.

While sols of (1) antimony sulphide, (2) cadmium sulphide, (3) manganese dioxide are not adsorbed by their respective precipitates, which have a tendency to pass readily into the colloidal condition when shaken in presence of the sols. These substances give rings of the second type which is made up of alternate layers of coagulated mass and the sol of the same substance usually having different colours.

Experimental results show that silver ions are only slightly adsorbed by silver chromate in the course of its formation, whilst chromate ions are not appreciably adsorbed by either silver chromate or lead chromate. Hence there is no direct experimental support in favour of Bradford's theory of Liesegang ring formation based on adsorption.

Adsorption of sols by their freshly prepared precipitates has a direct influence on the type of the rings produced. If the sol is coagulated and adsorbed by the respective precipitate, then rings separated by clear spaces are produced, but on the other hand, if the sol is not coagulated by its precipitate, then bands consisting of alternate layers of precipitates of different colours are formed.

33. Effect of time on the gelating sols.

S. S. Bhatnagar, N. A. Yajnik *and* Des Raj, Lahore.

Certain colloidal solutions undergo gel formation as a result of ageing. However it is uncertain whether ageing brings about a chemical change in the system or whether the change in the size of the aggregates is responsible for the above sol-gel transformation. The present investigation was undertaken to get decisive evidence on the point.

The following conclusions were arrived at :—

1. The gel formation, which is the result of ageing, showed small changes in refractive index.
2. The process of sol-gel transformation is a continuous one as shown by the smoothness of the time--refractive index and the time —viscosity curves.
3. There is a maximum gelation and minimum solation temperature for each concentration.
4. Three types of gels do not differ in their behaviour.
5. Temperature—refractive index curves do not mark off any sol-gel transition point.
6. Refractive index is the linear function of concentration.

34. Chromatic emulsions.

S. S. Bhatnagar, N. A. Yajnik *and* Ishwar Dass Bhalla, Lahore.

Holmes and Cameron were able to prepare chromatic emulsions by using collodion as an emulsifying agent but their emulsions were stable for a week or two. The authors have extensively studied the effect of the following :—

(*a*) Ratio of the phases.
(*b*) Nature and concentration of emulsifying agents.
(*c*) Temperature.

Chromatic emulsions can be classified into two kinds :—

1. Those which with rise in temperature change from blue *via* various shades to yellow ultimately.

2. Those in which the change of colours takes place in the reverse order.

Solid chromatic emulsions have been prepared with gelatine as the emulsifying agent. These emulsions coated thinly on glass produce very picturesque colour effects.

35. Studies in photo-sols. Part I.

S. S. Bhatnagar, N. A. Yajnik *and* Vasu Dev Zadoo, Lahore.

It has been shown that mixtures of As_2S_3, Sb_2S_3, silver and gold sols are sensitive to light. A series of colour changes has been observed to take place. The most effective wave-region has been determined. The effects of dilution and concentration of As_2S_3, Sb_2S_3, silver and gold sols have been investigated. It is shown that as a result of hydrolysis, silver and gold sulphides are produced and they produce the photo-sensitive centres, which are responsible for the phenomenon of colour changes.

36. Viscosity of sodium and potassium amalgams.

Mata Prasad *and* S. D. Bhave, Bombay.

The measurements of the interfacial tension of liquid sodium and potassium amalgams by Bhatnagar, Prasad and Mukerji (Journ. Ind. Chem. Soc., *1*, 81) have shown that compounds of sodium and potassium with mercury are formed even at very low concentrations of the alkali metal and that at all other concentrations, the amalgam is probably a solution of the compounds and the metal in mercury. To obtain further evidence for this view, the investigation of the viscosities of sodium and potassium amalgams was undertaken.

Wagstaff's method (Proc. Camb. Phil. Soc., XXI, 11, 1923) of measuring the viscosity of mercury was employed for this purpose.

The results obtained indicate that all the amalgams are more viscous than pure mercury. By plotting the coefficients of viscosity of the amalgams against the concentration of the alkali metals in the amalgams, curves have been obtained which show sudden breaks at about the same composition of the amalgams as observed by Bhatnagar, Prasad and Mukerji (*loc. cit.*). These observations lend additional support to the view of the formation of compounds of alkali metals and mercury even at very low concentrations.

37. Hydrolysis of ammonium carbonate solutions.

C. J. J. Fox *and* C. L. Mankodi, Bombay.

K. Buch (Zeit. für. Phy. Chem., 1910, *70*, 55,) investigated the hydrolysis of ammonium carbonate solutions. The value of the hydrolysis constant of ammonium bicarbonate obtained by him was about seven times smaller than the theoretical value calculated by the application of the law of mass action. The authors have re-investigated the problem introducing some modifications in Buch's method and using solutions far more dilute (from about $\frac{N}{5}$ to $\frac{N}{20}$) than those (about 4N) used by Buch, but have confirmed Buch's results. The cause of divergence between the theoretical and experimental values remains a matter for further investigation.

38. Change of electric conductivity of hydrophobe and hydrophile colloids on ageing.

N. R. Dhar, Allahabad.

Hydrophobe sols prepared in the cold show more marked increase of conductivity with time than sols prepared from hot solutions, because the adsorptive power of particles obtained in the cold is much greater than that of particles in the hot condition.

In the case of hydrophobe colloids, the electric conductivity and surface tension will increase and viscosity and adsorptive power and hydration and stability will decrease on ageing. On the other hand with hydrophilic substances like gelatin, egg-albumin etc. the stability, the degree of hydration, viscosity and adsorptive power will increase, whilst the electric conductivity and surface tension will decrease on ageing.

39. Some special features of organo-sols.

S. S. Bhatnagar, Lahore, *and* S. L. Bhatia, Bombay.

In this paper the authors have studied some properties of copper, silver and gold sols prepared with benzene as the continuous medium. The sols were prepared by Bredig's method and the following properties with regard to them have been studied :—

1. Nature of change.
2. Coagulation by electrolytes and non-electrolytes.
3. Action of heat.
4. Refractive indices.
5. Absorption spectra of the colloidal solutions were made with a quartz spectrograph using the continuous ultraviolet spectrum. The photographs show two types of absorption, general and selective. Photographs are reproduced.

40. Viscosity of sols in presence of electrolytes.

D. N. Chakravarti, Allahabad.

Viscosity measurements of not less than twelve hydrophobe sols in presence of various electrolytes have been carried on by the Farrow's method, and it has been found that when small quantities of electrolytes insufficient for coagulation are added the viscosity decreases due to the adsorption of ions carrying the same charge as the sol; but when greater quantities of electrolytes are added the adsorption of ions carrying the opposite charge become prominent and so the viscosity increases.

It has also been found that when $FeCl_3$ or HCl is added to a sol of ferric hydroxide there is marked decrease of viscosity than when KCl is added. This is ascribed to the greater adsorption of $Fe^{\cdot\cdot\cdot}$ or H·ions than K·ions. Viscosity measurements with $Fe(OH)_3$ and As_2S_3 sols in presence of KCl show that the decrease in viscosity is more prominent with As_2S_3 sol than with $Fe(OH)_3$ sol. This result confirms the views advanced from this laboratory that As_2S_3 is capable of adsorbing more of similarly charged chloride ions than $Fe(OH)_3$ can adsorb K·ions.

41. The effect of non-electrolytes on the coagulation of ferric hydroxide sol.

Subodh Gobinda Choudhury *and* Ashu Tosh Ganguli.

Coagulation experiments were performed with KCl, K_2SO_4, $K_3Fe(CN)_6$ in presence of different percentages of methyl alcohol, ethyl alcohol, pyridine ,oxalic acid, cane sugar, urea, glycerol. Adsorption experiments were

performed in presence of the above non-electrolytes with KCl and K_2SO_4. The adsorbability of KCl increases in presence of glycerol, cane sugar, and urea, whereas it decreases in presence of methyl alcohol and ethyl alcohol. Adsorbability of K_2SO_4 decreases in case of cane sugar, glycerol and urea. The sol is sensitized in presence of all the non-electrolytes studied except cane sugar. These observations can be explained on the basis of the two-fold effect of dielectric constant on the stability of a colloid, as pointed out by Mukherjee and Choudhury in previous papers.

42. The effect of dilution and of non-electrolytes on the coagulation of colloids.

Subodh Gobinda Choudhury *and* Nirmalapada Chatterjee, Calcutta.

Coagulation experiments were performed with copper ferrocyanide sols. With dilution of the sol, the coagulating concentration of KCl, and $BaCl_2$ decrease and then on further dilution of the sol they increase. Coagulation experiments with copper ferrocyanide sols in presence of methyl alcohol, ethyl alcohol, cane sugar, have been performed. The results have been discussed from the theoretical point of view.

43. On the independent activity of ions and on the annulment of the junction potential by saturated solution of potassium chloride.

Jnanendra Nath Mukherjee *and* Kali Kumar Kumar, Calcutta.

The electromotive forces of certain cells have been measured with the arrangement previously described.

The results obtained have been discussed in light of the theory of independent activity of ions and the annulment junction potential by saturated potassium chloride. Incidentally a further source of error in such measurements of activity has been pointed out.

44. The partition coefficient of organic acids between benzene and water as affected by neutral electrolytes.

Jnanendra Nath Mukherjee *and* Rama Prasad Mitter, Calcutta.

The partition of a number of weak organic acids between benzene on the one hand and water or aqueous solution of neutral salts on the other which are insoluble in benzene has been measured.

45. The effect of direct and alternating current electrolysis on adsorbed substances.

S. S. Bhatnagar, Lahore *and* S. L. Bhatia, Bombay.

In this paper the authors have tried to investigate the effects of direct and alternating current electrolysis in the removal of adsorbed copper and nickel sulphates from charcoal.

The results obtained may be summarised as follows :—

1. Direct current is capable of removing the adsorbed copper and nickel sulphate from charcoal.

2. The percentage extraction with one full battery volts (about 40) being 83·63% in the case of copper sulphate and only 50·66% in the case of nickel sulphate.

3. The time required for the neutral system to become acidic is very much less in the case of copper sulphate charcoal system than in the case of nickel: this being only 6 hours in the case of the former, while in the latter the electrolysis had to be carried out overnight before the solution could give any test for acid.

4. Alternating current of the type obtained from the secondaries of an induction coil has no effect on the adsorbed electrolytes.

46. On the nature of hydrolytic adsorption. Part II. Silver salts.

JNANENDRA NATH MUKHERJEE *and* JYOTI KANTO BASU, Calcutta.

Further experiments are described with insoluble silver salts showing the generation of acids or alkalis on the mixing of neutral solutions of salts.

47. Measurement of charge with mixtures of electrolytes.

JNANENDRA NATH MUKHERJEE *and* SATYAPRASAD RAY CHOUDHURY, Calcutta.

In a previous paper Mukherjee and Ghosh assumed the adsorption of an ion in order to explain certain observations on coagulation of colloids with mixtures of electrolytes. Measurements of charge under these conditions have been made and the results are discussed from the point of view of an ion adsorption and ionic antagonism.

48. Adsorption and coagulation of stannic hydroxide sol.

S. GHOSH, Allahabad.

Stannic hydroxide sol prepared by the method of Zsigmondy has been found to be a very good adsorbent for many electrolytes. Adsorption experiments with KCl, NaCl, $AgNO_3$, $CuSO_4$, $CuCl_2$, $HgCl_2$ and $BaCl_2$ at various dilutions of the electrolytes show that Freundlich's adsorption formula is followed. The sol being acidic in nature has been found to adsorb mostly the cations. The order of the amounts of adsorption for the electrolytes investigated is

$$CuSO_4 > CuCl_2 > HgCl_2 > BaCl_2 > NaCl > KCl > AgNO_3.$$

The adsorption of $CuSO_4$ is about 30% and of $AgNO_3$ is hardly 2% from M/50 solutions. In all cases a large amount of acid is liberated after the adsorption of cations.

Coagulation experiments have also been made with stannic hydroxide sol and it has been found that whilst this sol requires more of KCl, $BaCl_2$ etc. to coagulate a concentrated sol than a dilute one, greater quantities of $K_4Fe(CN)_6$ are required to coagulate a dilute sol than a concentrated one. This is because the sol does not adsorb any Cl' ions from KCl or $BaCl_2$, whilst measureable amounts of $Fe(CN)_6''''$ ions are adsorbed from $K_4Fe(CN)_6$. More of KCl than the calculated amounts are also required to coagulate this sol when it is coagulated with a mixture of $K_4Fe(CN)_6$ and KCl. Coagulation of this sol with a mixture of KCl and HCl show that the quantities of KCl smaller than the calculated amounts can bring about coagulation in presence of HCl. The presence of hydrogen ions in the colloidal solution is shown by the fact that the sol is distinctly acidic and shows a high conductivity. The addition of HCl tends to check the above decomposition and this is more pronounced with smaller amounts of HCl.

49. Photochemical decomposition of ferricchloride in alcoholic solutions.

K. D. Nigudkar, Bombay.

Alcoholic solutions of ferric chloride when exposed to sun-light yield ferrous chloride, HCl, an aldehyde and an alkyl chloride—corresponding to the alcohol employed. (Benrath, Journ. Prakt. Chem. Vol. 72, Page 220, 1905 and Vol. 80, Page 283, 1909.)

The author has found that the decomposition of ferric chloride into ferrous chloride and chlorine is the main photochemical reaction involved when alcohol and ferric chloride react in sunlight.

The method of investigation is to expose the alcoholic solution of ferric chloride to monochromatic radiations from a 750 Watt projection lamp for various intervals of time and to estimate the amount of ferric and ferrous chlorides in the solution after each interval volumetrically by using standardised sodium thiosulphate and iodine. Quantitative measurements of the rate of decomposition are in progress; the results will help to determine the order of the reaction. It is also proposed to test the applicability of Einstein's Law of Photochemical Equivalence to this reaction by the measurement of light energy by means of a thermopile.

The reaction does not appear to show the phenomena of "photochemical after-effect."

50. Further investigations on the photobromination of tartaric acid.

J. C. Ghosh *and* Kalipada Bose, Dacca.

The velocity of the dark reaction at 33° is negligible, and the induction period in the dark extends over several hours.

It has been found that for red, orange, yellow and yellowish green lights, the induction period is large but the reaction is monomolecular after the induction period is over. For bluish green, blue and violet regions of wave-length, the reaction is bimolecular and the induction period is nil.

It will be seen that with increased concentration of tartaric acid, the bimolecular photochemical reaction becomes monomolecular and as the initial concentration of bromine diminishes, the limiting concentration of tartaric acid at which this transition takes place becomes smaller. We have been able to confirm again a curious fact which we noted before viz. that the velocity constant increases as the initial concentration of bromine diminishes, and simultaneously the period of induction increases. It will also be noted that as the intensity radiation is reduced from 7 to 2 Hefners, the bimolecular reaction changes into a monomolecular one and the induction period considerably increases.

It has been found that for constant P_H the reaction is always monomolecular, the velocity constant is roughly proportional to $1\frac{1}{2}$ other conditions remaining the same; otherwise the reaction shows the same characteristics that were observed when tartaric acid alone was used as acceptor molecules.

51. Absorption of light in the ultraviolet by organic acids in presence of uranyl salts.

J. C. Ghosh *and* Jadulal Mukherjee, Dacca.

It is well known that organic acids generally decompose with splitting up of CO_2 when exposed to light in presence of uranyl salts. A thorough quantitative investigation of this process of photochemical decomposition has been undertaken. The measurement of the absorption of light by the solution of the acids and by uranyl salts separately, and in mixtures

of the same indicated that the additive rule is not followed. For the same wave-length the absorption co-efficient in a mixture is considerably larger than the sum of the absorption co-efficients of the component solutions. Not only this, but the region of absorption band is considerably extended towards the visible. A considerable change in colour on mixing two solutions often indicates a chemical change. It therefore appears possible, that when organic acids and uranyl salts are mixed together, an intermediate compound is formed whose absorption co-efficient is much larger than that of the components and which undergo decomposition on exposure to light.

52. Further investigations on the photobromination of cinnamic acid and stilbene.

J. C. Ghosh *and* R. M. Purkayastha, Dacca.

For the same intensity of white light the velocity constant is independent of the concentration of bromine ; it increases as the concentration of cinnamic acid increases and shows a very large temperature co-efficient—about 2·8 for a rise in temperature of 10°C. Similar results were obtained with stilbene.

Velocity co-efficient for white light both with cinnamic acid and stilbene as acceptor molecules increases a little more rapidly than the square root of intensity of incident radiation. Intensities are expressed in an arbitrary scale.

The velocity co-efficient varies approximates as $1\frac{1}{2}$. Its value in CS_2 is 2·5 times that in CCl_4 as solvent. Measurements of molecular extinction co-efficient of Br_2 in the two solvents were also carried out.

Similar exhaustive experiments were carried out in green and yellow light.

Einstein's law is not obeyed at all, and as the magnitude of the absorbed quantum increases, the number of molecules transformed increases very rapidly.

The temperature co-efficient increases as the wave-length of incident radiation increases, which appears to be remarkable.

Very similar results have been obtained with stilbene as the acceptor in photobromination.

Short periods of induction varying from five to twelve minutes have been observed in the above experiments and the values of velocity constants have been calculated with the concentration of bromine some ten minutes after exposure as the initial concentration. Corresponding to this period of induction, a small photochemical after-effect was also noticed in these experiments on photobromination.

53. Systems formed by water and reciprocal salt pairs. Part I. Phase reactions at the invariant points.

M. A. Hamid, Lahore.

By an application of Gibb's ζ-function, Schreinemakers (Die Heterogenen Gleichgewichte, Roozeboom) has developed graphical method for the determination of the phase reactions in equilibrium at the ternary invariant points in condensed systems. By the extension of these methods to the condensed quaternary systems formed by water and reciprocal salt pairs, an attempt is made to study the phase reactions which occur at the quaternary invariant points.

The application of the general laws of solubility to this type of quaternary systems in which double decomposition occurs often leads to complications. These are discussed and in the light of the phase reactions occurring at the isothermal invariant points, an attempt is made to lay down general rules for the investigation of these systems.

54. Systems formed by water and reciprocal salt pairs. Part II. The identification of solid phases.

M. A. Hamid, Lahore.

The application of Schreinemaker's "rest method," (Zeit. Phys. Chem., 1907,*59*,663) for determining the nature and composition of solid phases from analysis of equilibrium solution and of the wet (drained) mixture of solids, to systems formed by water and reciprocal salt pairs, is discussed with examples from the quaternary system,

$$H_2O–Na_2SO_4–NaNO_3–K_2SO_4–KNO_3,$$

recently investigated by the author.

55. Period of induction in chemical reactions. Part I: Interaction of mercuric chloride and sodium bicarbonate.

P. Neogi *and* Sukumar Neogi, Calcutta.

56. Studies in interfacial tension.

D. N. Ghosh *and* H. E. Watson, Bangalore.

A comparative study of the various methods of measuring interfacial tension has led to the development of a satisfactory method. By the use of this new method the interfacial tensions of partially miscible liquids have been found to be quite appreciable up to the critical point contrary to Freundlich's views.

57. The photochemical oxidation of toluene and benzaldehyde.

C. J. Kothari *and* H. E. Watson, Bangalore.

The oxidation of toluene in sunlight and in the light of the mercury arc has been studied using anthraquinone, benzoquinone, camphorquinone and uranium salts as catalysts. An apparatus has been devised for studying the oxidation of benzaldehyde in solution and various substances have been tried as possible catalysts and anticatalysts.

58. The preparation of ethers by the use of solid catalysts.

N. G. Gajendragad, S. K. Kulkarni Jatkar *and* H. E. Watson, Bangalore.

The equilibria in the reactions,

$$\text{(i)}\ 2\ CH_3OH \rightleftarrows (CH_3)_2O + H_2O$$

$$\text{and (ii)}\ 2\ C_3H_7OH \rightleftarrows (C_3H_7)_2O + H_2O$$

have been determined using potassium alum as the catalysts. The values of K_p in both cases correspond to 90% conversion.

59. Kinetics of the decomposition of mercuric formate.

A. A. Venkataraman *and* B. B. Dey, Madras.

In the course of some experiments, it was noticed that a specimen of pure mercuric formate began to decompose and turn black even when kept in perfect darkness; and exploded with great violence when heated in a small tube. It seemed to be of interest, therefore, to study the rate of decomposition of mercuric formate, both in the dark as well as in light, by observing the volume of carbon dioxide liberated at definite intervals

of time. The reaction was first carried out in the dark at the ordinary temperature (30°C) when it was found that the rate instead of falling off as would be expected, gradually increased to a maximum and then slowly diminished to zero. This is presumably due to the fact that the products of decomposition — either the formic acid or mercury or both catalyse the reaction so that the velocity increases at the beginning, the rate of decomposition thus appearing to depend on the resultant of two opposing forces, viz., the diminution in quantity of the active mass of the decomposing substance which tends to reduce the velocity, and the accumulation of the products of decomposition which by catalysing, tend to increase it.

On carrying out the reaction in light, the velocity of the reaction is found to be appreciably increased. From the measurements made in the two cases, it appears that the quantity of energy required for the *photochemical* decomposition is largely in excess of that demanded by Einstein's law of photochemical equivalence.

60. The action of cyclohexeneoxide on a solution of ammonium chloride.

Hemendra Kumar Sen *and* Chittaranjan Barat, Calcutta.

If to a saturated solution of NH_4Cl, cyclohexeneoxide is added and vigorously shaken, gradually alkalinity develops and the light oil which in the course of 3 days settles to the bottom is found to be cyclohexenechlorhydrin. The reaction is found in presence of an excess of ammonium chloride, to be monomolecular, but towards the latter part, side-reactions set in. The reaction has been studied both in heterogeneous and homogeneous media.

61. Bromination of benzene.

P. S. Varma *and* Badri Narayan, Benares.

Benzene has been brominated in presence of a mixture of fuming nitric and nitro-sulphonic acids and a good yield of bromo-benzene obtained. Sodium nitrite and concentrated sulphuric acid help also brominating benzene.

A mixture of fuming nitric and concentrated sulphuric acid is also effective in yielding bromo-benzene. The yield obtained in all these cases is much greater than the yield obtained by using nitric acid alone or sulphuric acid alone.

62. Nitration of naphthalene.

P. S. Varma *and* C. K. Menon, Benares.

Naphthalene has been nitrated and the yields of α-nitro-naphthalene obtained by the following nitrating agents compared: nitric acid alone; nitric acid mixed with concentrated sulphuric acid; nitric acid in presence of acetic anhydride; nitric acid in presence of quick lime; nitric acid in presence of plaster of Paris; nitric acid in presence of phosphorous pentoxide; a mixture of fuming nitric acid and nitro-sulphonic acid; sodium nitrate and concentrated sulphuric acid; sodium nitrite and dilute sulphuric acid; nitric oxide; nitrogen peroxide; and nitrous gases.

63. Iodination of aromatic hydrocarbons.

P. S. Varma *and* K. G. Rama Panicker, Benares.

Benzene, toluene and xylene have been directly iodinated in presence of sodium nitrite and fuming sulphuric acid and good yields of mono-iodo-derivatives obtained.

64. Simultaneous diazotisation and nitration of aromatic amino-compounds.

P. S. Varma *and* P. V. Krishnamurthy, Benares.

Diazotisation and nitration have been effected simultaneously by passing nitrous gases through the solution of the hydrochloride of the amino-compounds cooled in a freezing mixture.

65. A Comparative study of the influence of substituents in the benzene nucleus on nitration.

P. S. Varma *and* K. G. Rama Panicker, Benares.

Comparative measurements have been made of the influence of substituents in the benzene nucleus on nitration under as far as possible identical experimental conditions. The results obtained up till now show that the various groups or radicals can be arranged in the following order (the degree of nitration decreasing):—

NH_2; OH; NO_2; CHO; H; CH_3; COOH; Br; I; Cl; $NHCOCH_3$.

66. Syntheses of diaryl *p*-aminobenzamidines.

R. C. Shah, Bombay.

In continuation of previous work (*J. Ind. Inst. Sc.*, 7, Part X, pp. 205–223), diphenyl, phenyl-*p*-tolyl, and di-*p*-tolyl-*p*-aminobenzamidines have been synthesised. The method used was to convert the anilide or *p*-toluidide of *p*-nitrobenzoic acid into the imide-chloride, which by condensation with aniline or *p*-toluidine yields the corresponding nitrobenzamidine. The nitrobenzamidine is then finally reduced to the amino compound using iron and dilute acetic acid.

The following are further points of interest in the work.

1. Diphenyl-*p*-nitrobenzamidine has been found to possess the rare property of combining with a large number of solvents including saturated aliphatic hydrocarbons to form molecular compounds, whose composition invariably is two molecules of the solvent to one of the substance.

2. The action of phosphorous pentachloride on *p*-nitrobenz-*p*-toluidide has been found to give the imide-chloride and not an amido-chloride as stated by Gattermann and Neuberg.

3. Phenyl-*p*-tolyl-and di-*p*-tolyl-*p*-nitrobenzamidines, which have been described by Gattermann and Neuberg as colourless compounds of melting points 260° and 300° respectively, are found to be red and orange compounds of melting points 152° and 165° respectively.

67. Chromoisomerism in amidines. I.

R. C. Shah, Bombay.

The phenomenon of chromoisomerism, or the existence of the same substance in differently coloured modifications which has been so termed by Hantzsch, has not been hitherto met with in the case of amidines. The first observation of this kind was made by the author in the case of diphenyl-*p*-aminobenzamidine mono-hydrochloride which was obtained in two mutually convertible forms, one colorless and the other yellow.

To see whether the observation represented an isolated case or was of a more general nature, the following related compounds were prepared and examined in all possible ways for chromoisomerism:—diphenyl, phenyl-*p*-tolyl, and di-*p*-tolyl-*p*-nitrobenzamididines; their hydrochlorides, sulphates, and benzoyl derivatives and their reduction products, the aminobenzamidines.

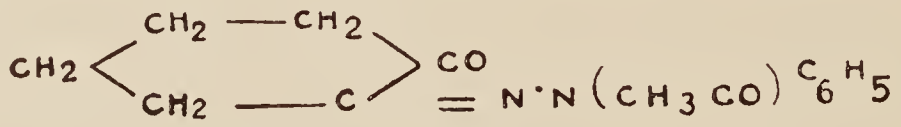
The phenomenon appears to be of more or less general occurrence in the compounds studied. In many instances, the two forms have been isolated and in some cases where this has not been possible owing to the instability of one of the forms at the ordinary temperature, the existence of this form is indicated by the thermotropic behaviour of the substance.

Experiments to determine the nature of the isomerism are in progress. Although no conclusive evidence is yet available, it is suggested that the chromoisomers may represent stereoisomers of the oxime type which are possible in the case of amidines on the Hantsch-Werner theory.

68. Interaction of diazonium salts with acetyl *cyclo*ketones.

Hemendra Kumar Sen *and* Sisir Kumar Ghosh, Calcutta.

If to an aqueous alcoholic solution of acetyl cyclohexanone in presence of sodium acetate, diazonium chloride solution is added, at first an oil separates which sets into a solid in course of time. This was found not to be the monophenyl hydrazone or *ortho* diketohexamethylene, as was expected from our experience of hydroxymethylene cyclohexanone but a compound having the chemical composition $C_{14}H_{16}N_2O_2$. The constitution of this series of compounds is probably represented by the formula



but its solubility in alkali is difficult to explain. The investigation is under progress.

69. Synthesis of phenylated ureas and thioureas.

J. N. Rây *and* R. M. Rây, Calcutta.

The interaction of urea with aromatic amines seems to be governed by the following reversible reactions :

1. $NH_2CONH_2 \rightleftarrows NH_4N : CO \rightleftarrows NH_3 + HN : CO.$
2. $HN : CO + H_2NR \rightleftarrows NH_2\ CO.\ NHR.$
3. $NH_2\ CO\ NHR \rightleftarrows NH_3 + RN : CO.$
4. $RN : CO + H_2NR \rightleftarrows NHR.\ CO.\ NHR.$

It follows that if an acid substance be present, all the forward reactions would be stimulated. This has been experimentally realised, for, when phosphorous pentoxide was added as a condensing agent, substituted ureas (mono and di) were formed at temperatures as low as 105–110°, the yield being 88 % in the case of dulcin and a few other substances. It also follows from the above mechanism of reaction that if a large excess of urea be used, monophenylated ureas would be exclusively formed, as there would be no free amine available for the fourth reaction.

70. The action of chloroform and carbon tetrachloride on certain mercaptans.

S. Krishna *and* Sajjan Singh, Lahore.

The experiments described are an extension of Reimer and Tiemann's reaction (Ber. 1876, IX, 1285). It has been found that unsubstituted thio-phenol gives thio-salicylaldehyde and thio-salicylic acid respectively together with a large quantity of di-sulphide.

Substituted thio-phenols, on the other hand, produce an acid from their disulphides.

The usual catalysts (reduced Cu and Hg etc.) employed in Reimer and Tiemann's reaction to improve the yield of the products (which usually is very low) are found to act as negative catalysts in the present experiments. Best yields, however, are obtained in aqueous solution without a catalyst and not in dilute alcohol as suggested by previous workers.

71. Nitro-acids of the β-resorcylic acid series and their salts.

M. G. Srinivasa Rao *and* B. K. Tirunarain Iyengar, Bangalore.

The following acids and their salts have been studied. The acids were prepared by oxidising the corresponding nitro-aldehydes with permanganate in hot magnesium sulphate solutions.

1. 5-nitro-4-methoxy-2-hydroxy benzoic acid, m.p. 228° decomp.
2. 5-nitro-4-2-dimethoxy benzoic acid, m.p. 216–217°.
3. 5-nitro-2-ethoxy-4-methoxy benzoic acid, m.p. 204–205°.

The barium, lead, potassium and silver salts of these acids have been prepared and their properties studied.

72. Condensation products of derivatives of β-resorcylic aldehyde.

M. G. Srinivasa Rao *and* C. Srikantia, Bangalore.

(I) 7-*Methoxy coumarin* has been obtained easily from 4-methoxy-β-resorcyl aldehyde, fused sodium acetate and acetic anhydride by refluxing in an oil-bath for 12 hours. M.p. 115–116°.

It does not give any colour with $FeCl_3$ and gives a blue fluorescence with conc. sulphuric acid.

(II) 6-*Nitro*-7-*methoxy coumarin* has been similarly prepared from 5-nitro-4-methoxy-β-resorcylic aldehyde. Yellow crystals. M.p. 184-5°. It also does not give any colour with $FeCl_3$ and no fluorescence with sulphuric acid.

(I) above was nitrated but the nitro compound thus obtained was not identical with (II).

(III) 3-*Acetyl*-7-*methoxy coumarin.*

This is obtained in quantitative yield from 4-methoxy-β-resorcylic aldehyde, ethyl acetoacetate and a few drops of piperidine (Knoevenagel). Deep lemon yellow crystals sparingly soluble in alcohol; give no colour with $FeCl_3$, m.p. 168-9°. It dissolves with an orange red colour in conc. sulphuric acid and gives a reddish blue fluorescence.

(IV) 3-*Acetyl*-6-*nitro*-7-*methoxy coumarin* was obtained in the same way as (III) using 5-nitro-4-methoxy-β-resorcylic aldehyde. Yellowish red crystals m.p. 220–230° (decomp.). (III) was nitrated and the product thus obtained was found to be different from (IV).

(V) ω Nitro-styrenes of β-resorcylic aldehyde derivatives could easily be obtained from the corresponding aldehydes, nitromethane and ammonium acetate as condensing agent in alcoholic solutions. Primary and secondary amines (Knoevenagel, Ber., 1904, *37*) had little effect in this respect or gave but poor yields. Better yields were obtained when along with ammonium acetate some ½ cc. of acetic acid also was used in order to keep down the concentration of OH ions. 4-methoxy-β-resorcylic aldehyde, 2 : 4-dimethoxy benzaldehyde and 2-ethoxy-4-methoxy-benzaldehyde all condensed easily.

5 nitro-4-methoxy-β-resorcylic aldehyde however condenses with nitro-methane and methylamine hydrochloride.

2-hydroxy-4-methoxy-ω-nitrostyrene	.. m.p.	171-2°.
2 : 4-dimethoxy-ω-nitrostyrene	..	104°.
2-ethoxy-4-methoxy-ω-nitrostyrene	..	100-1°.
2-hydroxy-4-methoxy-ω : 5-dinitrostyrene		214°.

73. Substitution in resorcinol derivatives—Part IV.

M. G. Srinivasa Rao *and* M. Sesha Iyengar, Bangalore.

During the preparation of the monobromo derivative of 4-methoxy-β-resorcylic aldehyde (Ind. Sc. Congress, 1926), when excess of bromine was continually present, a large quantity of a white crystalline substance, crystallisable from hot water, was obtained. The substance did not give the Beilstein test, thereby showing the absence of the halogen. $FeCl_3$ gave a violet colouration. M.p. above 250°. This is perhaps an anhydro aldehyde.

A number of bromo compounds of the derivatives of β-resorcylic aldehyde was prepared with a view to find out the factors affecting the position of an entering group in tri-substituted benzene derivatives.

(I) 2 : 4-Dimethoxy benzaldehyde was brominated in presence of sodium acetate in acetic acid solution and the product thrown into water when a white crystalline substance, m.p. 136-7°, was got.

(II) When (I) obtained above was oxidised in a hot solution of $MgSO_4$ by permanganate, white needles, m.p. 195° were obtained identical with 2 : 4-dimethoxy benzoic acid brominated in the usual way.

(III) 2-Ethoxy-4-methoxy benzaldehyde brominated as in (I) yielded white needles, m.p. 125-6°, which was identical with the ethylated product of the monobromo derivative of 4-methoxy-β-resorcylic aldehyde.

(IV) p-Methoxy salicylic acid was brominated and the white solid, m.p. 250°, has bromine in position 5. (Fries and Saftien, Ber. Dtsch. Chem. Ges. 59. 1246–54.) The methyl ester of p-methoxy salicylic acid on bromination and subsequent hydrolysis with alcoholic potash yielded a product identical with the bromo-p-methoxy salicylic acid (above) so that the ester as well as the acid which would dissociate, gets the bromine in position 5.

The position taken by bromine in these is discussed.

74. Hydrolysis of anilides of 2 : 3-oxynaphthoic acid.

Gourikanta Mukherjee, Calcutta.

The compound, β-oxynaphthoic anilide is known in commerce as 'Naphthol AS.'

The hydrolysis of this substance was required for the purpose of identifying certain dyes. Schöff who has described 2 : 3-oxynaphthoic anilides (Ber., *25*, pp. 2740–45) merely states that on being boiled with alkalis oxynaphthoic anilide gives aniline.

On attempting to hydrolyse 'Naphthol AS' with alkalis only a faint odour of aniline was noticed, the presence of which was confirmed by the *iso*cynaide reaction. Other hydrolysing agents such as sulphuric and hydrochloric acids were employed, but in all cases 'Naphthol AS' remained unchanged. On heating it, however, with fuming hydrochloric acid (sp. gr. 1·2) in a sealed tube at about 180°C for five hours, the substance hydrolysed into aniline and 2 : 3-oxynaphthoic acid. On crystallisation from hot water, the acid was obtained pure which melted at 215°-216°C—the melting point of 2 : 3-oxynaphthoic acid itself.

Similar behaviour was also noticed in the case of other anilides of 2 : 3-oxynaphthoic acid.

75. Reactivity of the double bond in coumarins and other $\alpha\beta$-unsaturated carbonyl compounds. Part I: Addition of cyanacetamide.

I. R. Seshadri, Madras.

The double bond in coumarin differs greatly with regard to its reactivity from that in other $\alpha\beta$-unsaturated carbonyl compounds, the effect being probably due to the pyrone ring structure. The action of cyanacetamide not only throws light on this question but offers a method for producing a series of reduced coumarin derivatives having asymmetric carbon atoms. The reaction is carried out in boiling alcoholic solution in the presence of a trace of piperidine which is found to be essential. With coumarin the addition becomes complete within four hours whereas in the case of similar compounds like cinnamic acid or ester and coumaric acid no reaction could be detected even after prolonged heating.

3 : 4-dihydro-coumarin-4-cyanacetamide has been hydrolysed in stages to yield the following acids : (1) 3 : 4-dihydro-coumarin-4-cyanacetic acid, (2) 3 : 4-dihydro-coumarin-4-acetic acid, (3) *ortho*-hydroxy phenyl-β-glutaric acid.

Similar compounds are obtained from 6-nitro-, 6-amino-, 7-methyl and 3-acetyl coumarins as also benzylidene acetone with cyanoacetamide.

76. Condensation of benzylidene ketones with cyanacetamide.

Hemendra Kumar Sen *and* Sailajaranjan Majumdar, Calcutta.

With benzylidene acetone and cyanacetamide in the presence of diethylamine or piperidine, no less than five condensation products have been isolated. Their constitution is discussed, whereby the theory of the reactivity of the ethylenic linkage in a conjugated double bonded system is amplified. Reaction product of dibenzylidene cyclohexanone with cyanacetic ester is also described, of which the constitution is not yet definite.

77. The condensation of ketones with resorcinol and similar other compounds. Part II.

Rajendra Nath Sen *and* Nalin Chandra Chatterjee, Calcutta.

In the present investigation various types of ketones (aliphatic, aromatic, cyclic, etc.) have been condensed with resorcinol by heating the substances together with powdered anhydrous zinc chloride in an atmosphere of hydrochloric acid gas, the reaction taking place in the following manner:—

$$\begin{matrix} R \\ R \end{matrix}\!\!>\!CO + 2\,C_6H_4(OH)_2 = \begin{matrix} R \\ R \end{matrix}\!\!>\!C\!<\!\begin{matrix} C_6H_3(OH) \\ C_6H_3(OH) \end{matrix}\!>\!O + 2\,H_2O$$

Besides the condensations of resorcinol with various ketones, those of hydroquinone, pyrogallol and diethyl-*meta*-aminophenol with the typical aromatic ketone, benzophenone have been studied under similar conditions, and in all these cases tetraphenyl methane derivatives with a pyrone ring have been obtained. Similarly Michler's ketone has been condensed with diethyl-*m*-aminophenol, and camphor has also been condensed with hydroquinone, etc., etc.

The most striking fact about the various condensation products described in this paper is that though they do not admit of quinonoid configuration yet they are all coloured compounds producing more or less deeply coloured solutions with caustic alkalis in the case of hydroxy compounds, or with acids (in the case of basic compounds) and also possessing dyeing properties in varying degrees. Thus they form an interesting group of non-quinonoid dyes.

78. Note on the preparation of *iso*vanillic acid.

P. C. Mitter *and* Nirmalananda Palit, Calcutta.

In connection with some synthetic operations we were in need of *iso*vanillic acid and *iso*vanillin. The following method for the preparation of the former was found to be suitable.

Starting from anethole, it is converted by nitration into nitroanisic acid which on reduction with alcoholic ammonium sulphide gives amino-anisic acid. This is diazotised in the usual way and the diazotised solution is run into a mixure of sodium-sulphate and sulphuric acid heated to 135–145°. The *iso*vanillic acid is extracted with ether and purified by sublimation.

Attempts at reduction of the *iso*vanillic acid to *iso*vanillin have so far not been attended with success.

79. Some indol and acridine derivatives containing an α-pyrone ring and their intermediate products.

T. R. Seshadri, P. Krishnamurti, *and* B. B. Dey, Madras.

The following have been prepared :—

(1) ω-6-*Amino-coumaryl acetophenone* m.p. 210° ;
(2) 6-*Coumaryl-glycine* m.p. 343° ; *nitroso derivative* m.p. 156-157° ; *ethyl ester* forming yellow needles m.p. 123° and its *nitroso* derivative m.p. 113° ; *acetyl* derivative of the glycine m.p. 122°.
(3) *Indolo*-5 : 4-α-*pyrone*, m.p. 138°.
(4) Iso*nitroso acetaminocoumarin.* Colourless crystals m.p. 240° (decomp.).
(5) 2 : 3-*diketo-indolo*-5 : 4-α-*pyrone*, orange red crystals m.p. 225–227° (decomp.), dissolving in dilute caustic soda with a deep red colour and reprecipitated unchanged on acidification. The indophenin test with commercial benzene led to the production of a deep green colour. The *imino* derivative, colourless fibrous crystals m.p. 240–242° (decomp); the *phenyl imino* derivative m.p. 232–234° (decomp.) ; *benzoyl* derivative colourless needles m.p. 320° (decomp.) and phenyl hydrazone red cubical crystals m.p. 266–68° (decomp.) were prepared.
(6) 6-Coumaryl anthranilic acid m.p. 247°.
(7) Acridono-2: 1-α-pyrone crystallises from pyridine in yellow needles melting and decomposing above 350° and showing a bright green fluorescence in alcohol or acetic acid solution. Attempts to prepare the indigo molecule annealed to a pyrone ring are in progress.

80. Coumaryl-4-acetic acid. Part II. Some derivatives and condensations with *o*-hydroxy aldehydes.

D. B. Limaye, Poona.

Following up the recent synthesis of coumaryl-4-acetic acid by the author, the preparation of crystalline salts of the acid with copper and

silver has been described. Ethyl ester of the acid melts at 116°. This on condensing with salicylic aldehyde in the presence of piperidine yields unsubstituted 4 : 3′-dicoumaryl, melting point 246°. *p*-aramethoxy salicylic aldehyde also can be brought into reaction.

81. Condensation of ethylcyclohexanone carboxylate with phenols.

Umaprasanna Bose *and* Hemendra Kumar Sen, Calcutta.

Ethylcyclohexanone carboxylate has been condensed with resorcinol in the presence of strong sulphuric acid in the cold, when 3 : 4-benzotetrahydro-7-oxy-coumarin (?) was obtained. In view of the doubt thrown on the possibility of a chromone condensation in such reactions, by Baker and Robinson, it was deemed advisable to investigate into the mechanism of the reaction.

82. α-Pyridino-acenaphthenequinone.

Anukul Chandra Sircar *and* Manmatha Nath Roy Choudhury, Dacca.

The present investigation was undertaken with the object of preparing an *ortho*-diketone containing a heterocyclic ring in its molecule and studying the properties of the diketone, compounds of which types do not seem to be known. Miss Hibbert (Trans. Chem. Soc., 1924) prepared the hydrocarbon α-pyridino-acenaphthene. By careful oxidation of the hydrocarbon it has been found possible to convert it into the *ortho*-diketone α-pyridino-acenaphthenequinone. The properties of the diketone has been thoroughly studied and its oximes, hydrazones and semicarbazones prepared. The diketone has also been condensed with a number of *ortho*-diamines, and aldehydes in presence of ammonia to yield a series of azines and iminazoles respectively. The tinctorial properties of the azines and iminazoles so obtained have been compared with those of the corresponding compounds obtained from phenanthraquinone and acenaphthene quinone.

83. Synthesis of O-alkyl ketones from hydroxymethylene ketones.

Hemendra Kumar Sen *and* Kanai Lal Datta, Calcutta.

When an absolute alcoholic solution of hydroxymethylene cyclohexanone is treated with the requisite amount of sodium ethoxide, and then with an excess of methyl iodide and heated on the water bath with a reflux condenser and a guard tube, till neutral, two products are formed—*ortho*methyl cyclohexanone, and the methyl ether of the enolic hydroxymethyl cyclohexanone. If the methylation is conducted in a benzene suspension of the sodium salt of hydroxymethylene cyclohexanone, the product is mainly the methyl ether of the aldehyde form of the hydroxymethylene ketone. On treatment even with cold alcoholic potash, pure *ortho*methyl cyclohexanone is generated. This can be easily identified by means of the semicarbazone. Ethyl cyclohexanone and dimethyl cyclohexanone have similarly been prepared in the pure condition. The oxime of the latter has been obtained only in the *syn*-form.

84. Synthetical experiments on the *iso*-quinoline alkaloids.

J. N. Rây, Calcutta.

The method successfully adopted by Perkin, Rây, and Robinson in their synthesis of oxy-berberine is now extended to the synthesis of other

similarly constituted alkaloids. Perkin, Haworth, and Rankin showed that the Pictet synthesis of berberine cannot be experimentally realised. Hence a synthetical method was developed for the synthesis of berberine. On the exact knowledge of the structure of berberine depended the constitution of several alkaloids of which palmatine is one. The constitution for palmatine was arrived at by Späth and Lang (1921) in the following manner: Oxyberberine was heated with alcoholic potash in a sealed tube at 150°. The phenolic substances (not characterised) thus obtained were then methylated and from the product, oxypalmatine was isolated. As Haworth, Perkin, and Rankin threw doubt on the synthesis of berberine and also as they obtained all sorts of products, by the action of alkali on oxyberberine in a sealed tube, it is deemed necessary to synthesise palmatine. By the application of cyanhydrin reaction on opianic acid α-cyano meconine is obtained from which α-carboxy meconine is obtained by hydrolysis. The chloride of this is now condensed with various β-alkylated ethyl amines. The amides thus obtained are converted into *iso*quinoline derivative. These on reduction pass to substances analogous in constitution to oxyberberine. The compound from 3 : 4-dimethoxy-β-phenyl ethyl amine is oxypalmatine.

85. The constitution of the acid formed by the action of sulphuric acid on camphorquinone.

M. B. Bhagvat *and* J. L. Simonsen, Bangalore.

The acid formed in this reaction, which was considered formerly to be *d*-2 : 2 : 4-trimethyl*cyclo*hexan-3-one-1-carboxylic acid, is now shown to be *d*-2 : 2 : 3-trimethyl*cyclo*hexan-4-one-1-carboxylic acid.

86. *iso*Erucic acid.

B. J. Mirchandani *and* J. L. Simonsen, Bangalore.

The authors show that *iso*erucic acid is an inseparable mixture of Δ^{11}-dokesene-1-carboxylic acid and Δ^{13}-dokesene-1-carboxylic acid.

87. Some derivatives of acenaphthpyridine.

S. Unni Nair *and* J. L. Simonsen, Bangalore.

The authors have investigated the condensation of 5-aminoacenaphthene with paraldehyde and ethyl acetoacetate and describe some derivtives of acenaphthpyridine.

88. Thiodiazines. Part VI.

Prafulla Kumar Bose, Calcutta.

1-*p*-Tolylthiosemicarbazide reacts with halogenated ketones and the products are similar to those derived from 1-phenylthiosemicarbazide (see Part V). They are, however, hydrolysed by boiling dilute hydrochloric acid to ammonia and a keto-thiodiazine.

The condensation products consequently are regarded as iminothiodiazines.

2-Imino-4-*p*-tolyl-5-phenyl-2 : 3-dihydro-1 : 3 : 4-thiodiazine, m.p. 193°d; mono acetyl derivative, m.p. 147°.

2-Imino-4-*p*-tolyl-5-methyl-2 : 3-dihydro-1 : 3 : 4-thiodiazine, m.p. 168-69°; monoacetyl derivative m.p. 155°.

2-Keto-4-*p*-tolyl-5-phenyl-2 : 3-dihydro-1 : 3 : 4-thiodiazine, m.p. 210-11°.

2-Keto-4-*p*-toyl-5-methyl-2 : 3-dihydro-1 : 3 : 4-thiodiazine. m.p. 771°.

89. Studies in the thiosemicarbazone series.

PRAFULLA KUMAR BOSE *and* DHIRENDRA CHANDRA RAY CHOUDHURY, Calcutta.

Attempts have been made to convert thiosemicarbazones of unsaturated aldehydes and ketones (cinnamic aldehyde and benzalacetone) into pyrazoline derivatives. But the expected transformation could not be effected even by glacial acetic acid, which is, as a rule, very helpful in bringing about the transformation in the case of phenylhydrazones of unsaturated ketones and aldehydes. This behaviour of the thiosemicarbazones is attributed to the structure, RNH. C(SH)=N.N−C(R′)−CH=CH.R″ which has already been proposed by one of us for thiosemicarbazones in general.

90. Thiodiazines. Part V.

PRAFULLA KUMAR BOSE, Calcutta.

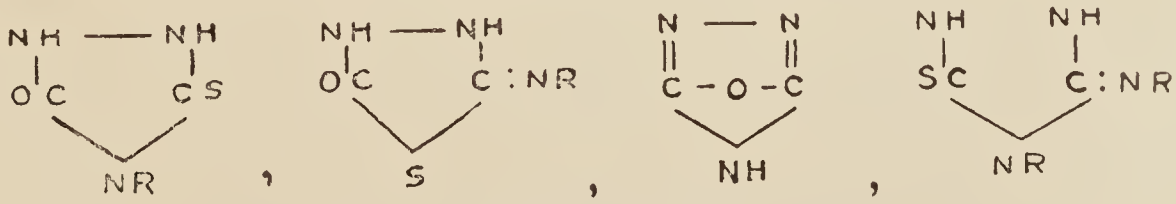
1-Phenylthiosemicarbazide condenses with halogenated ketones like monochloracetone, ω-bromacetophenone and p methyl-ω-bromacetophenone in alcoholic solution at the ordinary temperature. The bases thus obtained give characteristic colorations with conc. sulphuric acid, produce monoacetyl derivatives on acetylation with acetic anhydride and are easily converted by the action of hot dilute hydrochloric acid into isomeric bases which can also be obtained if the reaction between the thiosemicarbazide and the chloro- or bromo-ketone is carried out in boiling alcoholic solution. The isomerides do not show any colour reaction with conc. sulphuric acid, and form diacetyl derivatives. The constitution of these bases is under investigation.

The base derived from monochloracetone has the composition, $C_{10}H_{11}N_3S$, m.p. 179°; acetyl derivative, m.p. 132°. Its isomer melts at 181°; acetyl derivative, m.p. 252°. The base derived from ω-bromacetophenome, $C_{15}H_{13}N_3S$ melts at 191°; acetyl derivative, m.p. 161°. The isomeride has m.p. 194–5°; its acetyl derivative melts at 285°. The base derived from p-methyl-ω-bromacetophenone has m.p. 186°d and the composition $C_{16}H_{15}N_3S$; acetyl derivative, m.p. 146°. Its isomer melts at 181–82°; acetyl derivative does not melt below 280°.

91. Action of urea upon semi- and thiosemi-carbazides. Simultaneous formation of thioketo-triazoles, imino : keto-thiobiazoles, endoxytriazole and amino : thiol-triazoles.

P. C. GUHA *and* P. C. SEN, Dacca.

Monosubstituted thiosemicarbazides react with urea to yield simultaneously four different compounds and their formation can be nicely explained on the assumption that the thio-semicarbazides react both in the *syn* and *anti* forms. The following four types of compounds are formed from phenyl, tolyl, and xylyl thiosemicarbazides.



(where R=Phenyl, tolyl, xylyl.)

The endoxy compound is formed almost in a quantitative yield when urea acts upon semicarbazide, to the exclusion of other compounds.

92. Some interesting syntheses in the thiobiazole and oxybiazole series.

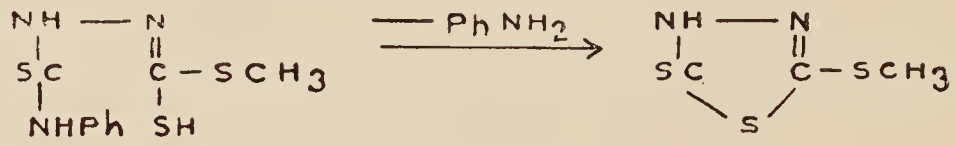
P. C. Guha *and* S. C. Guha, Dacca.

Thiocarbimides and carbimides react with methyl-dithiocarbazinate to yield 4-R-thiosemi- and 4-R-semicarbazide-methyl-dithiocarboxylates respectively. Thus 4-Phenyl, tolyl, xylyl, allyl-thiosemicarbazide-1 : methyldithiocarboxylates and 4-phenyl(naphthyl)-semicarbazide-1-methyl-dithiocarboxylates have been prepared.

Ph. NH-CS-NH. NH-CSSMe loses one molecule of hydrogen sulphide when it is simply heated with alcohol, forming 2-phenylimino-5-methyl thiol-2 : 3-dihydro-1 : 3 : 4-thiodiazole.

Acetic anhydride brings about an analogous reaction and there is formed a closed ring compound, 2-phenylmino-3-acetyl-5-methylthiol-2 : 3-dihydro-1 : 3 : 4-thiodiazole which can be readily deacetylated.

The action of concentrated hydrochloric acid is also attended with a new type of ring closure thus :—

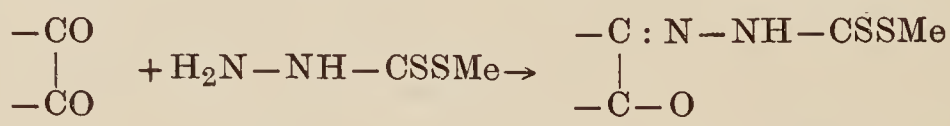


Ring closure of Ph.NH-CS-NH-NH-CSSMe is effected also with caustic soda solution.

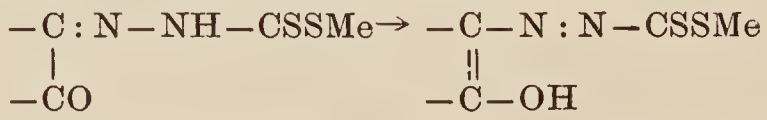
93. Action of *ortho*diketones, their monoximes and chlorides and esters of dibasic acids on methyl-dithiocarbazinate.

P. C. Guha *and* S. C. Guha, Dacca.

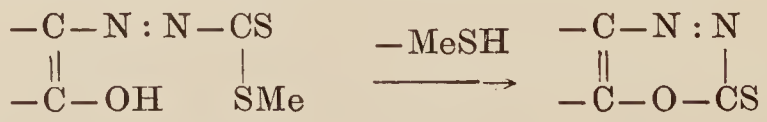
Methyldithiocarbazinate reacts with *ortho*-diketones thus :



The hydrazone-methyldithiocarbazinate thus formed then assumes the azo structure by migration of one hydrogen atom thus :



Similar cases of migration resulting in the change of hydrazones into azo-compounds are well known. The azo compound then loses a molecule of methyl mercaptan giving rise to an oxydiazine compound thus :



These compounds are insoluble in alkali.

With isatin, however, the reaction proceeds in a slightly different fashion—isatin itself furnishes a hydroxyl group—and there is thus no necessity for the assumption of a change from hydrazone to azo structure as in the foregoing reactions. The isatin compound possesses mercaptanic properties.

Phenanthraquinone monoxime gives a thio-hepta-triazine compound. The action of six different acid chlorides viz. (*a*) thionyl, (*b*) oxalyl, (*c*) Phthalyl, (*d*) fumaryl, (*e*) succinyl and (*f*) carbonyl upon the carbazinate has been studied and five, six, and eight-membered heterocyclic compounds have been obtained.

94. Benzidine inversion in bis-hydrazocompounds.

P. C. Guha *and* H. K. Banerjee, Dacca.

Symmetrical diphenyl thiocarbohydrazide and sym-diphenyl-carbohydrazide undergo benzidine inversion to yield diamino-diphenyl-thiourea and diamonodiphenyl-urea respectively, which as well as their hydrochlorides get oxidised in air very quickly to yield brownish black tarry products. Their isolation being found to be impossible, a good number of characteristic reactions have been tried directly with the inverted solution to prove the presence of amino groups.

To ascertain the position of the aminogroups in the inverted diamino-diphenyl-urea, the *p* : *p*-diaminodiphenyl urea was synthesised thus :—

$$COCl_2 + 2NH_2C_6H_4NO_2(p) \rightarrow CO(NHC_6H_4NO_2)_2 \xrightarrow{H_2} CO(NHC_6H_4NH_2)_2$$

and the synthesised product was found to be a quite different substance from the compound obtained by inversion. So, it is evident that diphenyl carbohydrazide has not undergone a *para* inversion. By applying the above process of synthesis employing ortho-nitraniline to start with, and on subsequent reduction of the *o* : *o'*-dinitrodiphenyl urea, slight indication as regards the identity of the inverted compound with *o* : *o'*-diamino-diphenyl-urea has been obtained.

95. An attempt towards the synthesis of *o*-thiol-phenyl-hydrazine : Synthesis of diphenylene-1 : 4 : 5-oxydisulphide.

P. C. Guha *and* S. C. Guha, Dacca.

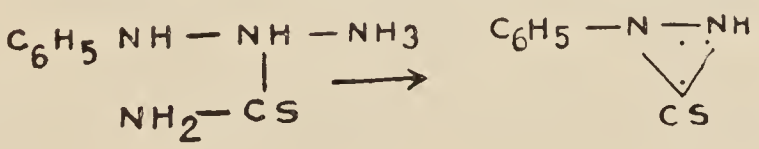
orth-Amino-thiophenol reacts with nitrous acid to give a diazo sulphide and from this on reduction Jacobson could only obtain thianthrene (Ann. *277*, 209).

An attempt has now been made for obtaining the desired thiol-hydrazine from the disulphide of *o*-aminothiophenol. But, the diazo-salt could not be reduced to the corresponding hydrazine derivative. The diazo compound is decomposed and a brownish tarry matter is obtained which furnishes on steam distillation a pale yellow oily product possessing the empirical formula $C_{12}H_8S_2O$. Evidently, the diazo-salt yields in presence of water the unstable o : o'-dihydroxy-diphenyl disulphide which in its turn loses a molecule of water to yield *o* : *o'*-diphenylene-1 : 4 : 5-oxydisulphide. Diphenylene-1 : 4 : 5-oxydisulphide gives on reduction *o* : *o'*-di thioldiphenyloxide possessing characteristic mercaptanic properties. This is the first instance that the synthesis of a seven-membered ring-compound containing two sulphur and one oxygen atom in the ring is achieved.

96. Constitution and mechanism of formation of the so-called phenyl-sulphocarbazine of Emil Fischer.

P. C. Guha *and* H. K. Banerjee, Dacca.

By heating 1-phenlythiosemicarbazide with 20% HCl in a sealed tube Fischer (Ann. 1882, *212*, 326) obtained a compound $C_7H_6N_2S$, HCl from which the free basic compound was liberated by alkali. He explained the loss of one molecule of ammonia in the formation of the new compound which he called phenyl-sulphocarbazine, thus :—



The work of other investigators on this subject viz. Freund and Goldsmith (Ber., *21*, 2466), Pinner (Ber. *21*, 2331), Harries and Loewenstein (Ber. *27*, 861.), who ascribed different wrong formulae to Fischer's phenyl-sulpho-carbazine, has now been criticised and it has been shown that the compound really possesses an amino group which can be diazotised. The amino group reacts with mustard oils, isocyanates and benzaldehyde to yield the expected thiocarbamides, carbamides and benzylidene compounds respectively. In the opinion of the present authors, phenyl sulphocarbazine is really 2 : 3-benzo-5-amino-1 : 4-thiazole.

97. Influence of the sulphur atom on optical rotatory power.

P. P. Shukla, Bangalore.

Aromatic derivatives of imino-and bisimino-camphor have been shown by Forster, and by Singh and their collaborators to display very high rotatory power ; by examining the corresponding thio-derivatives, the effect of a sulphur atom on rotatory power in this group is determined.

Preparation of thio–bases required for condensation with camphor–quinone presented unexpected difficulties. These bases, e.g., thioaniline, have been known for many years, but the experimental details are insufficiently described, or presented in a manner unhelpful to other workers. Accordingly the methods have been re-examined, in almost all cases with improved yield. Condensed with camphorquinone, they gave derivatives of thioiminocamphor which have been compared in respect of rotatory power with the corresponding sulphur-free compounds, when it was found that the introduction of sulphur had a depressing effect on the rotation.

98. Action of cuprous hydride on diazoniun salts.

P. Neogi *and* Anil Krishna Mitra, Calcutta.

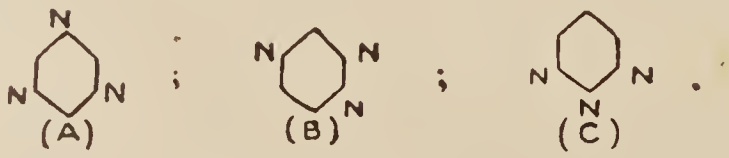
99. A new scaly variety of aluminium hydroxide.

P. Neogi *and* Anil Krishna Mitra, Calcutta.

Whilst studying the action of aluminium mercury couple on the solutions of the salts of oxy-acids of nitrogen, chlorine, bromine and iodine we were struck with the extremely lustrous, crystalline nature of the precipitates of the aluminium hydroxide which was formed in each case. The most brilliant and sparkling scales are obtained when aluminium amalgum reacts on barium nitrate solution. The scales that are deposited are thoroughly washed with large volumes of water and dried with alcohol and ether. The vacuum dried samples have composition Al_2O_3, $4H_2O$. They are quite stable and a sample kept for three weeks in a desiccator was found not to lose more than half a molecule of water. At 100° one molecule of water goes away and the last molecule is removed by heating it in a combustion furnace.

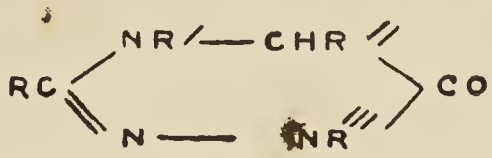
100. Syntheses in the triazine series.

Monmohan Sen, Calcutta.

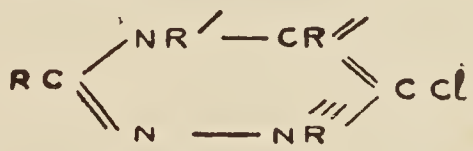


Of the three possible types of triazines A, B an C, type B seems

to have been very little studied—few derivatives of this type being known. Triazines of this class of the form



with R=Me and Ph, R′=Ph,*o*-tolyl and *α*-naphthyl, R″=H and Me, R‴=Ph and *β*-naphthyl have been synthesised and their properties studied. They were synthesised from the fragments R-CO-NR′—CHR″—COOH and NH_2—NHR‴ by heating in alcoholic solution on the water-bath for several hours. The products are all fine crystalline bodies and are neutral due obviously to the presence of the CO group. By the action of PCl_5 chloro-derivatives of the type



are obtained which on reduction are expected to give simple triazines. Compounds were also obtained from RCONH-CHR′—COOH and NH_2′ NHR,‴ the analysis of which points to their being the expected triazines. But the absence of sharp melting points leads one to suspect that the products are mixtures of triazines and triazoles. Further work is in progress on this line.

101. On Inene—a new tricyclic sesquiterpene present in the oleoresin of *Dipterocarpus tuberculatus*.

P. C. Mitter *and* Nirmalananda Palit, Calcutta.

The oleo-resin of *Dipterocarpus tuberculatus* gives on steam distillation about 30% of sesquiterpenes boiling between 135°–142° at 13 m.m.

On oxidation with chromic acid 84 c.c. of the oil gave 32 grms. of sesquiterpene boiling at 125–130 at 5 mm.

On heating over sodium in *vacuo* under reflux.

B.P. 125°−126° at 5 mm. $a_D = +44°$
Density at 27°=0·8961 n=1.4870. Mol. ref=65.1
$C_{15}H_{24}F$=64.46
Diff=0.64

Found: C=88.0; H=12.09.
Calculated for $C_{15}H_{24}$ C=88.2 H=11.8

Further oxidation with chromic acid gives on fractionation a substance with a lower rotation the analytical data for which agrees with the formula $C_{15}H_{24}$.

Attempts at desulphurisation give with copious evolution of H_2S a blue oil which does not give a solid picrate.

Reduction with spongy platinum gave dihydroinene.

B.P.=123°−125°/5 mm.
Found: C=87·4; H=12·9.

Calculated for $C_{15}H_{24}$
C=87·3; H=12·6.
Density at 27°= 0·8886. n= 1·477. $a_D = -10°$
Mol. Ref.=65.5
$C_{15}H_{26}F_0$=64.84

Diff=0·66.

The molecular refraction both of inene and of its dihydro derivative agrees with that of a tricyclic sesquiterpene with a cyclopropane ring.

Inene gives Turner's colour reaction with sodium nitrite and glacial acetic acid like tricyclen-gurgunene.

It gives a liquid hydrochloride which decomposes on distillation even at a pressure of 10 mm.

102. The bitter principle of "Neem" oil.

RAJENDRA NATH SEN *and* GANAPATI BANERJEE, Calcutta.

An account of the work on the odourous and bitter principle of Neem oil was published by Watson, Chatterjee, and Mukerjee in J.S.C.I. 1920, Sept. 30.

They ascribed the objectionable odour of the oil to the presence of slightly volatile organic sulphur compounds and bitterness to the presence of resinous acids in some form of esters.

In the present investigation, the bitter substance obtained by shaking the oil with hot water is found essentially different from Watson's bitter compounds in the fact that it differs from their bitter substances by its containing sulphur in the molecule. It also differs from their bitter principles by its percentage composition and other physical and chemical behaviour. This substance exists in the oil chiefly in the form of soluble sodium salt. On being acidified with dil. HCl, this salt gives yellowish precipitate (P) which turns brown on exposure to air and light. The filtrate on concentration gives crystals of NaCl.

100 grs. of the oil yield nearly ·05 gr. of the crude product (P).

The crude product (P) is found to be a mixture of two acids, one (main portion m.p. 203-208°) is soluble in chloroform and contains sulphur, and the other is insoluble in chloroform, and decomposes above 270° and does not contain any sulphur.

103. Oil from the seeds of *Asteriastigma macrocarpa* (Fam. Bixineæ.)

B. B. DEY, Madras.

The chemical investigation of the constituent of this oil was recently undertaken in view of the recommendation of its use for the treatment of leprosy and other skin diseases. The following preliminary results are now recorded. Benzene extracts nearly 40 per cent. of a crystalline fat having the following constants:—

Sp. gr. at 30° = ·9340; m.p. = 37°·2;
Saponification value = 194; Iodine value = 38 ·3;
Refractive index at 60° = 1·4575; M.P. of the fatty acids = 45°·3.

The melting points of both the fat and the fatty acids rise on standing for a few days.

104. The resin, 'Mahisakshi gugul' (Balsomodendron mukul).

D. SATYANARAYANA NAIDU, Calcutta.

The resin yields on extraction with light petrol a viscous golden-yellow liquid, having an agreeable aroma characteristic of the original resin.

Distillation of this liquid under a pressure of 9 mm. yields fractions 22·2% below 180°, and 11% between 180°-200°, while the rest begins to undergo decomposition. The fractions are esters in nature; and they are examined separately.

Ether extract of the residual resin yields a dark-red gummy substance (yield 13%) which when treated with alkali in ethereal solution yields a crystalline acid which takes a pretty long time before solidifying out of the resinous product. The pure acid, obtained in needles from a mixture of ether and petrol or better still from hot water, has m.p. 170°—171°, and neutralisation value 154 (yield 0·2%).

Hydrolysis of the gummy substance with alcoholic potash yields a yellow acid crystalline powder, m.p. 136°—140° (probably a mixture), and also a neutral resinous product which hardens into a brittle mass.

The water extracts, etc., of the residual resin are also examined.

105. Hydrogenation of "Nag-kesar" (*Mesua ferrea*) oil.

Gouri Kanta Mukherjee, Calcutta.

The oil from the seeds of *Mesua ferrea* (natural order Guttiferae) is known in Bengal as "Nag kesar" oil. The seeds yield 30% of fixed oil and the kernels alone 70% of the oil by ether extraction. The oil thus obtained has a deep yellow colour and forms orange coloured mixtures with sulphuric and nitric acids. The hard pericarp contains a considerable amount of tannin. The seeds are so oleagenous that when merely shelled and dried, they burn with a luminous flame. The oil is usually expressed by country *Ghannies* with a yield of about 60% of the kernel. The chief principle of *Mesua ferrea* oil appears to be an oleo-resin which abounds in all parts of the tree and is obtained pure from the young fruits.

The sample of oil examined was expressed in a country *ghanny* from genuine seeds. The oil was quite clear and had a yellowish brown colour with a characteristic objectionable odour. The analytical constants of the oil was found to be as follows :—

Saponification value	202·7
Iodine value	84·5
Acid value	10
Reichert-Wollney value	5
Specific gravity at 29°C	0.9218
Refractive index at 26°·5C	1·4740

The oil was then hydrogenised by both the dry and wet methods with metallic nickel as a catalyst. The objectionable odour of the oil was removed and the oil was found after 3 hours to have hardened with an iodine value of 38·9. This can then be used for soap manufacture.

106. Preparation of 4-acetylamino-3-chloro-phenyl stibinate of sodium.

Sudhir Chandra Niyogy, Calcutta.

This compound has been prepared by an entirely different method by Brahmachari and Das (Journal of Indian Medical Research, Vol. 13, p. 17) 4-Acetylamino-3-chloro aniline is diazotised in dilute hydrochloric acid solution and treated with a solution of antimony trichloride in concentrated hydrochloric acid. A crystalline additive compound immediately separates. This is filtered off and washed. The substance was beaten up with water and decomposed by gradually adding caustic soda with vigorous stirring. After the decomposition, the liquid is filtered off and the filtrate acidified when the free acid separates. This is dissolved in the least quantity of caustic soda to give the required monosodium salt.

107. Gas volumetric estimation of-SOOH in sulphinic acids

S. Krishna *and* Bhagwan Dass, Lahore.

The method employed is a modification of the Kux's method for carboxy acids which proceeds according to the following equation :

$$6R.SOOH + 5\ KI + KIO_3 = 6\ R.SOOK + 3I_2 + 3H_2O$$

$$3I_2 + 6KOH + 3H_2O_2 = 6KI + 6H_2O + 3O_2$$

The conditions of the experiment represented by the above equation are such that halogen substituted products usually result, with the elimination of the sulphinic group, as is well known in case of sulphonic acid derivatives. By suitable modifications, good results may be obtained in accordance with the equation.

The mechanism of the reaction probably is :—

$$R.\ SOOH + I_2 = R.\ SOOI$$

$$R.\ SOOI + H_2O_2 + 2KOH = R.\ SOOK + KI + 2H_2O_2 + O_2.$$

108. Estimation of-SOOH and Fe‴.

S. Krishna *and* Harnam Singh, Lahore.

Sulphinic acids cannot be estimated quantitatively by titrametric methods in cases where other negative groups are present in the molecule. The method employed now depends upon the complete precipitation of sulphinic acids as ferric salts in cold solutions. Since no such precipitates are obtained when ferrous salts are employed, the method can also be employed for the estimation of Fe‴ in a mixture with Fe″ ; and satisfactory results have been obtained. The formation of sulphinates of such metals as nickel and cobalt which occur with iron in the periodic table or chromium and aluminium which are closely related to iron in the quantitative analysis have also been studied ; and it is found that such sulphinates if at all formed, are unstable under the above experimental conditions. The method is, therefore, found to be applicable where it is desired to isolate Fe‴ from the metals.

109. Acetylation of diamine.

Khwaja Habib Hasan, Hyderabad.

Various methods of monoacetylation of *p*-phenylenediamine were tried and their rates studied.

It was found that acetylation of hydrochloride with 45—50% sodium acetate yielded only 60—65% p-acetyl compound, while 10gm. of *p*-phenylenediamine hydrochloride on boiling for an hour with 40 grams of acetic anhydride increased the yield to 70—75%. The maximum yield of 80% was obtained after first neutralising the hydrochloride with sodium carbonate and treating the substance with molecular proportion of acetyl chloride.

110. The effect of dyes and the various processes of dyeing on the lustre of silk fabrics.

S. S. Bhatnagar, N. A. Yajnik *and* Narinjan Nath Sarin, Lahore.

The Adam Hilger Nutting's spectrophotometer has been used to measure accurately the lustre of silk fibre in various spectral regions. The effects of the following on the lustre of fibres have been studied :—

1. The temperature of the bath.
2. Nature of the bath.

3. Concentrations.
4. Tension on the fibre.
5. Chemical nature of the dyestuff used and the results offer useful guidance to the practical dyer in maintaining and enhancing the lustre imparted by his dye-stuff.

111. Studies on invertase. Part I.

B. N. Sastri *and* Roland V. Norris, Bangalore.

Preparation of the enzyme from yeast and its purification. With the final product both Millon's test for protein and the Molisch test for carbohydrates gave negative results. The xanthoproteic reaction was positive and a very faint biuret reaction was obtained. The purified enzyme was of extremely high activity.

112. A simple method for concentrating enzyme solutions.

B. N. Sastri, Bangalore.

By freezing the dilute enzyme solution which is at the same time kept well stirred, most of the enzyme can be obtained in the mother-liquor separated from the ice crystals. Using autolised yeast liquors and malt extracts, a five-fold concentration has been obtained in three operations. Under these conditions the enzyme naturally undergoes no deterioration.

113. Studies in the proteins of Indian grains. Part I. Ragi (*Eleusine coracana*).

N. Narayana *and* Roland V. Norris, Bangalore.

An investigation of the prolamin or alcohol-soluble portein of "Ragi".

On hydrolysis only small amounts of basic nitrogen are obtained. The amide nitrogen figure on the other hand is high. Tryptophane and tyrosine are both present. A residue is always left after acid hydrolysis which is possibly similar to the analogous product obtained in the hydrolysis of wheat gliadin. The nature of this is being investigated.

114. Urease content of seeds of several Indian plants.

P. B. Sen, Calcutta.

To find out the urease content of several indigenous plants, their seed powders were tested for the power of splitting urea into ammonium carbonate. If the amount of ammonium carbonate formed be the index of the urease content and if the urease of jack bean of white variety be taken as 100 then urease content of jack bean (white) *Canavalia ensiformis*, is 79, Sona Mung (*Phascolus euraus*) ·012, Mash Kalai (*Var. Roxburghii* Prain) ·568, Mushri (*Lens esculeuta Moench*) ·156, But (*Cicer arietinum* Linn) ·376, Chota Mater (*Pisum arvense*) ·92, Bara Matar (*Pisum sativum*) ·954, Arahar (*Cajanus indicus* Spreng.) ·53, Khesari (*Lathyrus sativus*) 2·08, China Badam (*Arachis hypogaea* Linn) ·44, Almond (*Amygdalus communis*) ·47, Batabi Lebu (*Citrus decumana* Linn) ·48, Lebu (*Var. acida* Brandis) 3·4, Kumra (*Cucurbita pepo DC*) ·38, Lau (*Legenaria vulgaris* Ser) ·24, Barabati ripe (*Vigna catjang*) ·78, Barabati green (*Vigna Catjang*) 1·14.

115. Some physical properties of urease and method of obtaining it in purer form.

P. B. Sen, Calcutta.

Many methods of separating globulin from the aquous extract of jack bean meal was tried. In every case except precipitation of globulin by

saturation with NaCl whole of the urease comes down with the globulin. When the globulin was totally removed the albuminous portion was found to be free from urease. The effect of temperature was studied, the inactivation beginning at 58°C was complete at 80°C. This also follows the change of globulin by coagulation. So urease must be one of the following: (1) a globulin, (2) a globulin-urease complex, (3) a substance having the same physical property as globulin but is not a globulin. The possibility of its being one of them discussed and methods were adopted to get samples of urease free from protein. Adsorption by animal charcoal and subsequent elution; and fractional precipitation of globulin by acetone splits the globulin-urease complex into a protein free component and a comparatively pure portein. These themselves are not very strong enzymes but become very potent when mixed together. Their properties are being further studied.

116. A microchemical method for locating urease within cell.

P. B. Sen, Calcutta.

The exact location of the urease within the cell was found out by soaking the tissue in a solution containing a mixture of 85% alcohol, ·1% calcium chloride, ·1% urea. Ammonium carbonate formed acts upon calcium salt and precipitates the insoluble calcium carbonate. Sections were prepared from the tissue and thoroughly washed free from all soluble salts and kept in 1% silver nitrate for a few minutes and again washed free from silver nitrate. This section was devoloped with amidol developer. Urease containing places were stained black. For accuracy a control section was examined side by side. Sections of stomach of carnivorous animal and jack bean seeds were examined.

117. Studies on amylase from *Andropogom sorghum*, Part I.

V. N. Patwardhan *and* Roland V. Norris, Bangalore.

As sources of enzyme both malted and unmalted grains have been employed and the results thus obtained compared with the hydrolysis brought about by enzyme derived from barley, potato starch being used as substrate. The effect of the experimental conditions, e.g. reaction, presence of salts, temperature, etc., on liquefaction and saccharification respectively has been studied.

118. Studies on amylase from *Andropogom sorghum*, Part II.

V. N. Patwardhan *and* Roland V. Norris, Bangalore.

Investigation of the intermediate products in the hydrolysis of starch by the amylase of *Andropogom sorghum*.

Using *malted* grain as source of enzyme two compounds have been isolated possessing the following constants:—

Dextrin I. R=3·6; $(\gamma)_D = +174°·8$

Dextrin II. R=5·3; $(\gamma)_D = +155°·9$

With amylase from *unmalted* cholam the products obtained were

Dextrin III. R=0; $(\gamma)_D = +170°·6$

Dextrin IV. R=1·0; $(\gamma)_D = +185°·7$

R signifies the reducing power compared to glucose as 100

119. Cyclohexeneoxide and its hydrolysis by yeast.

HEMENDRA KUMAR SEN *and* CHITTARANJAN BARAT, Calcutta.

To a briskly fermenting solution of sugar, cyclohexeneoxide dissolved in alcohol was gradually added with the expectation of finding fresh evidence of the presence of reductase in yeast. A very small quantity of the expected cyclohexanol was obtained, but quite an appreciable amount of the glycol was also isolated, indicating thus the influence of the hydrolytic action of enzyme. In aqueous solution at ordinary temperatures, the hydration tendency is extremely slow. This is probably due to its very low solubility in water. In aqueous alcoholic solution, however, the rate of hydration is distinctly pronounced, but in contact with fermenting yeast the hydration is many times more rapid. 1 : 2-cyclohexane-diol so obtained is the *trans* form, melting at 104°, and is devoid of optical rotation.

120. The estimation of iodine in soils.

D. A. RAMA RAO *and* ROLAND V. NORRIS, Bangalore.

Accurate estimations of iodine in soils are of importance in view of modern theories on the origin of goitre.

The authors find that the methods now in use tend to give low results particularly in soils containing much iron.

A modified method has been devised which has given satisfactory results with check soils containing known amounts of added iodine.

121. The sedimentation method of mechanical analysis of soils.

M. R. RAMASWAMI SIVAN, Coimbatore.

It was shown in a former contribution that the tube sedimentation method of mechanical analysis of soils was closely comparable to the official beaker sedimentation process. In the present paper, the actual timings of deposits of the conventional fractions, as determined by the tube sedimentation method, are given.

Fine gravel is separated by standard 1 mm. sieve. The sieved fine earth is boiled with water in a beaker and the contents are poured into the long tube (150 cm. long and 20 cm. wide) which is filled with water and then inverted upright over a small flat procelain dish kept in a basin of water. The porcelain dish is replaced at stated intervals, as deduced from experiments with different types of soils, as mentioned below :—

Coarse sand (·2 mm. to 1 mm. diam.) 2 minutes 15 seconds.
Fine sand (·04 to ·2 mm. diam.) 12 minutes 10 seconds.
Silt (·01 to ·04 mm. diam.) 2 hours 10 minutes.
Fine silt (·002 to ·01 mm. diam.) 24 hours.
Clay (below ·002 mm. diameter) beyond 24 hours.

The method is simple, quickly done, is fairly accurate for most purposes and can be finished in one day.

The apparatus will be demonstrated.

122. Cyclic processes involved in the manufacture of sodium nitrate from Chilean caliche.

M. A. HAMID, Lahore.

Some recent inventions based upon a systemic study of the chemistry of solutions arising from the leaching of caliche are discussed. It is suggested that the information supplied may be profitably applied to the Indian saltpetre industry.

123. Principles governing the application of manures to paddy and the determination of assimilation factors.

M. R. Ramaswami Sivan, Coimbatore.

Summary of previous work on the availability of raw mineral phosphate is given, showing that, in conjunction with green manures, the mineral phosphate is available to the paddy plant, especially if a soluble nitrogenous manure is also added.

The comparative merits of bonemeal and mineral phosphate as suppliers of phosphoric acid, and of several organic manures as suppliers of nitrogen, are discussed, based on field and pot experiments.

In devising suitable manure mixture for the Cauvery delta, it is shown that the prices of indigenous manures which comprised the departmental mixture, which has found favour with the ryot, had greatly increased, and that the prices of imported chemical fertilizers had gone down, calculated on unit values. Kellner's work in Japan on the fertilizer requirements of paddy is discussed; and, following Kellner's plan, experiments were put down in one-square-yard Cuddappah slab frames sunk in the puddle in the wetlands of the Coimbatore Farm, with different manure mixtures, each containing the same quantities of nitrogen and phosphoric acid. The yields are given and, after subtracting the manurial ingredients of the no-manure plots, the quantities of nitrogen and phosphoric acid assimilated from the different manures and recovered in the crops, are calculated. These assimilation factors compare closely with Kellner's figures.

Simultaneously field experiments were put down with a specially designed manure mixture in the districts; and the increased yields obtained are shown.

The experiments are being continued during the year 1926-27.

124. Extraction of papain from papaya.

H. D. Sen *and* E. R. Watson, Cawnpore.

The paper deals with the optimum conditions for the extraction of papain—variations that take place in the yield and proteolytic activity of the juice that flows from papaya under different conditions: successive lancings, maturity of the fruit, number of cuts, etc., and also in different botanical varieties.

125. Castor cake fodder.

H. M. Mulany *and* G. J. Fowler, Cawnpore.

Though rich in nitrogeneous matter, ordinary castor cake is useless as fodder on account of the presence in it of a small quantity of ricin, a highly toxic albumin. A method, capable of being used on a large scale, has been worked out for rendering this cake harmless as animal food.

126. A rapid method of detecting adulteration in Ghee.

D. Y. Athawale, Cawnpore.

A method based on the refractive index of the fats and oils which will show in a short time (say 5 minutes) whether a particular sample of Ghee is adulterated or not.

The chief adulterants in Ghee are referred to.

127. Attempts to prepare citral, geraniol or similar open chain turpenes or menthol from turpentine especially from Indian turpentine.

H. M. Mulany *and* E. R. Watson, Cawnpore.

Pinene has been converted into dipentine by heating under pressure. The product is hydrogenated almost completely to hexahydro-*p*-cymene, which gives a chlorination product with the same boiling point as menthyl chloride. But menthyl chloride, even when obtained from ordinary menthol, does not give back secondary menthol on hydrolysis or by Grignard's reaction.

The pinene fraction of Bareilly turpentine does not give even dipentine under similar treatment.

The main fraction of Indian turpentine (B.P. 160–170) (first quality Bareilly turpentine) also fails to give dipentine on autoclaving.

128. Cymene from ajwan oil.

S. R. Bhate *and* Khwaja Habib Hasan, Hyderabad.

Locally obtained seeds of Ajwan (*Carum copticum*) yield only about 2% crude oil. The proportion of crystallisable thymol to uncrystallisable oil is almost 1 : 2. The uncrytallisable oil was examined for its constituents and was found to contain mostly a fraction which distills under ordinary pressure at 174°—176°C; the specific gravity of the oil is 0·846; it has a rotation of +1·75. This fraction yields over 45% cymene, identified by forming barium salts of its sulphonic acid, which corresponds to the formula (C_{10} H_{13} SO_3) Ba. $3H_2O$ and by formation of terephthalic acid on oxidation. The remaining fraction contains an unidentified terpene having the boiling point of cymene.

129. Storage of 'Mohwa' flowers.

S. R. Bhate, *and* Khwaja Habib Hasan, Hyderabad.

Mohwa flowers as stored in the godowns of distilleries rapidly deteriorate in moist weather when moisture to the extent of 25% is absorbed and partial fermentation sets in. The flowers also assume a charred appearance and the yield of alcohol is greatly affected. To prevent this deterioration experiments were undertaken in which the fresh flowers kept in stoppered flasks under various conditions, viz., (1) sun dried, (2) dried by artificial heat, (3) in the atmosphere of carbon dioxide, (4) in the atmosphere of sulphur dioxide. The flowers were examined periodically for a period extending over four years for their sugar contents and yield of alcohol and it was found that under all these conditions the flowers had kept very well; whereas the controls that were kept in open flasks gradually crumbled to dust or became mouldy. The need for properly storing the flowers is thus obvious. If a number of air tight chambers of suitable dimensions are constructed and after fumigating them, filled with sun-dried flowers and closed air tight, the sugary contents of flowers can be retained unchanged.

130. Study on the formation of pure tricalcium sucrate.

E. R. Watson, K. C. Mukerjee, *and*
H. S. Chaturvedi, Cawnpore.

Difficulties were found in preparing this substance in proper yield and purity in our method of separating out sugar from molasses which was complicated by the simultaneous formation of mono- and dicalcium sucrates. The whole precipitate was gelatinous and absorbed much

impurities. A detailed study was, therefore, necessary to find out the exact conditions under which pure tri-calcium sucrate in a granular or crystalline form would be formed. The precipitate obtained by Steffen's process in the cold is not true tri-calcium sucrate, as most of it dissolves away on boiling with water.

After a good deal of experiments it was found that only by boiling a solution of mono- or dicalcium sucrate for a sufficient length of time could pure crystalline tricalcium sucrate be obtained, which can be thoroughly washed with hot water for purification.

131. Formation of quinicine during sterilisation of quinine hydrochloride.

KHWAJA HABIB HASAN, Hyderabad.

It is well known that when quinine or cinchonine or their salts are heated with acids—organic and inorganic, they are changed, into their toxic isomers quinicine and chinchonicine.

The rate of change increases with the p_H. of the acid.

With very dilute N/10,000 acetic acid, about 95% is changed, while N/1 mineral acids produce only 2—3% (Biddle). The conversion is independent of dilution (Rabe).

To test whether toxic quinine is produced during the time that quinine hydrocholoride is heated for injection purposes, various experiments were tried.

The different methods of estimating quinicine are dependent on taking the difference between the amount originally taken and that which is recovered. None of these methods are very accurate. Method dependent on the change of rotation was tried and found to be remarkably accurate for very small concentrations. In higher concentrations dark colour of the quinicine mars the accuracy.

On boiling 10% solution of quinine bihydrochloride for 30 minutes no change in rotation is noticed. After 30 minutes up to the 6th hour there is a distinct fall in rotation and at the end of 12 hours about 5% is changed and goes on rising upto 24 hours when no further change takes place. The maximum amount changed was found to be 7·8%.

Further experiments on other salts are in progress.

132. Quick method of determining adulteration in Madras bark-tanned skins and hides.

K. SESHACHALAM CHOUDARY, A. GUTHRIE, *and* E. YOGANANDAM, Madras.

Although leather is formed by the combination of hide substance and tannin, yet several adulterants are added to give weight to the leather, chief of those used in Madras tanneries being epsom salts and sugar. The degree of adulteration is usually determined by analysing a sample of the leather. This is not possible in a tannery without a laboratory and even where there is a laboratory, takes conesiderable time. A weighed piece of leather is soaked in water for about two hours, dried, and reweighed. The loss in weight, along with the percentage of ash in the leather, has been found to give an indication of the degree of adulteration to very near that determined from an analysis of the sample of leather.

133. Studies in 'Avaram' bark.

K. SESHACHALAM CHOUDARY *and* E YOGANANDAM, Madras.

Avaram (Turwar, *Cassia auriculata*) is the premier tanning material of South India. It grows wild and is not cultivated and hence the supply of the bark is less than the demand for it. It is rather poor in

tannin content as compared with other available tannin materials, its tannin content varying from 15 to 19 %. The tannin content varies with age, the mature bark containing more tannin than the younger bark. Loss in the tannin content of liquors from Avaram is very little when compared with other tanning materials. This is an advantage indeed. Avaram diffuses into the hide rapidly. Leather tanned with this material is of very light colour, but darkens very quickly on exposure to light with a decrease in the strength of the leather.

134. Effect of neutral salts on the basicity of chrome liquors.

B. B. Dhavale *and* B. N. Pal, Calcutta.

The neutral salt effects of potassium and sodium sulphate on the basicity of one bath chrome liquor were studied. It was observed that the effects were due both to the cations and anions. Addition of sodium sulphate to sodium bichromate liquor or of potassium sulphate to potassium bichromate liquor decreases the basicity, whereas the addition of sodium sulphate to the potassium bichromate or of potassium sulphate to the sodium bichromate liquor tends to increase the basicity.

135. Correction of lactometer readings for temperature.

M. R. Ramaswami Sivan, Coimbatore.

Lactometers are so graduated that the readings denote the correct specific gravities only when the milk is at a temperature of 60°F. When the temperature is higher than this—as is very often the case in India—a correction is made by adding a fraction—usually ranging from a ·10 to ·20—to the lactometer reading for every degree °F above 60°F. A careful scrutiny of published tables reveals that this correction is exactly 1/200 of the lactometer reading, when the milk is at 85°F. It is shown how the correction may be more correctly applied for every lactometer reading and for every temperature.

136. On the nature of Kohlschutter's silver sol.

P. S. Macmahon *and* M. R. Nayar, Lucknow.

The authors have investigated the formation of silver sol and repeating the work of Pauli and Erlach, are unable to agree with these workers that if the materials used are pure no sol is produced by Kohlschutter's method. On the contrary, using different methods of purification, stable sols were readily produced at all temperatures tried between 25° and 90°C. A later paper by Pauli and Perlak appears to contradict Pauli's earlier work and confirm the present investigation.

137. Dilatometric investigations of enzyme action.

M. Sreenivasaya, Bangalore.

A special form of dilatometer has been devised suitable for the study of enzymes. Hydrolysis is accompanied by a decrease in the volume while the synthetic activity of the enzyme is indicated by an increase in the volume of the reaction mixture. Amylase, emulsin, invertase and lipase have been studied dilatometrically with a view to find out the most suitable enzyme that lends itself to the study of the mechanism of enzyme synthesis.

138. Enzymes of the lac insect with special reference to carboxylase.

M. Sreenivasaya, Bangalore.

A study of the enzymes of the blood of the lac insect was undertaken with a view to find out the digestive and synthetic enzymes responsible for alimentation and synthesis of the secretion products.

Invertase, maltase, catalase, esterase and carboxylase, as measured by their activity, were found to be present in appreciable quantities. Oxidase and per-oxidase were distinctly present while the action of lipase, proteoclastase, and reductase, although feeble, was unmistakable.

A special study of carboxylase has been undertaken since its presence in the lac insect rendered it all the more significant in view of its complete absence in allied coccids, including its nearest relation, the pseudolac insect.

139. Interaction of sulphur dichloride with substances containing the reactive methylene ($-CH_2-$) group.

Kuverji Gosai Naik *and* Ganesh Vishram Jadhav, Baroda.

The work was undertaken with a view (1) to throw some light on the reactivity of the hydrogens of the methylene group, in compounds containing the grouping $-CO.CH_2.CO-$, and (2) to study how far these reactions could throw light on the debated and vexed question of the constitution of sulphur dichloride. The reactions of (1) malondiphenylamide, (2) malondi-*o*-tolylamide, (3) methylon-di-phenylamide, (4) methylmalon-di-*o*-tolylamide, (5) malon-di-*α*-napthylamide, (6) malon-di-*β*-napthylamide, (7) malon-di-*n*-propylamide, (8) malon-di-*p*-tolylamide, (9) malon-di-benzyl amide and (10) methylmalon-di-*p*-tolylamide with sulphur dichloride were studied.

Compounds (1), (2), (3) and (4) reacted in a similar manner giving rise to, in case of (1) and (2), $(R.NH.CO)_2C<^{SCl}_{SCl}$, and in the case of (3) and (4), $(R.NH.CO)_2C<^{CH_3}_{SCl}$, where R may be a phenyl, or a tolyl group. Compounds (5), (6) and (7) react to give $(R.NH.CO)_2\,C<^{H}_{SCl}$ where R may be a naphthyl or a propyl group. These latter are unstable compounds losing all their sulphur and chlorine on nitration. Compounds (8) and (9) react differently giving $(R.\,NH.CO)_2\,C<^{Cl}_{SCl}$ where R may be a tolyl or a benzyl group. In the case of compound (10) which is a derivative of methylmalonic ester, the methyl group is also involved in the interaction, giving

$$(R.NH.CO)_2\,C<\begin{matrix}CH_2\\ |\\ S\\ /\backslash\\ Cl\quad Cl\end{matrix}.$$

Products derived from compounds (1), (2), (6) and (10) were nitrated. In all cases nitration of the aromatic nuclei occurred, but as a result of nitration, all of them lost their sulphur and chlorine, giving rise to

$$(R.NO_2.NH.CO)_2.CH_2$$

where R was either a phenyl, tolyl or napthyl group.

The results go to show beyond doubt that sulphur dichloride reacts neither as a mixture of sulphur monochloride and chlorine, nor as a mixture of sulphur tetrachloride, sulphur monochloride and chlorine. Sulphur dichloride is, therefore, a definite chloride of sulphur, having the formula SCl_2.

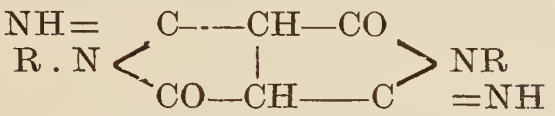
140. Interaction of sulphur monochloride with substances containing the reactive methylene group, $(-CN . CH_2 . CO-)$.

KUVERJI GOSAI NAIK *and* YESHWANT NARAYAN BHAT, Baroda.

The reactivity of the hydrogens of the methylene group depends on the sum total negativity of the groups attached to the carbon atom of the group. Whereas one of these negative groups, viz.-CN-was common to all the compounds subjected to investigation, the negativity of the other group was made subject to alterations, the total negativity being thus slowly altered.

(1) Cyanacetanilide, (2) cyan-acet-*p*-toluidide, (3) cyanacet-*o*-toluidide, (4) cyanacet-*m*-toluidide, (5) cyanacetxylidide, (6) cyanacet-α-napthylamide, (7) cyanacetbenzylamide were made to interact with sulphur monochloride. It was found that a condensed product of the type

resulted, which in view of the intense colour and stability of these compounds appears to undergo an imino transformation of the type



This receives further support from the work of Thole and Thorpe (J. 1911, *99*, 422–448), where transformation on a similar line is noted.

Some of these products were nitrated with fuming nitric acid, stable nitro compounds being obtained. The nitro groups entered the aromatic nuclei.

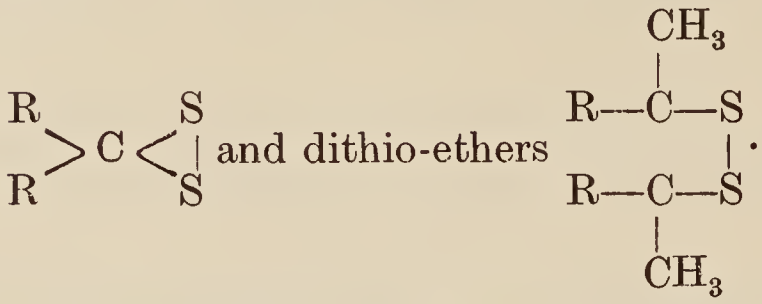
141. Condensation of cyanacetic ester with some aryl and alkyl amines. Preparation of some aryl and akyl subsituted cyan-acetamides.

KUVERJI GOSAI NAIK *and* YASHWANT NARAYAN BHAT, Baroda.

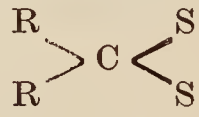
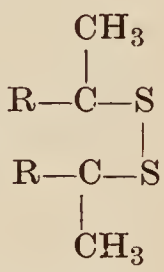
The method adopted in the preparation of these compounds was a modification of that employed by Freund (Ber, 1884, *17*, 134), and Whitley (J. 1903, *83*, 24), in the preparation of malondiphenylamide.

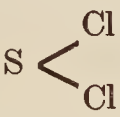
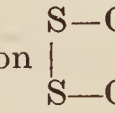
(1) Cyanacet-*o*-toluidide, (2) cyanacet-*m*-toluidide, (3) cyanacet-α-naphthylamide, (4) cyanacet-β-naphthylamide, (5) cyanacet-xylidide, (6) cyanacetmethylamide and (7) cyanacet ethylamide, were prepared for the first time. The methods employed had to be varied with the varying basic nature of the various amines, more drastic methods being employed in the case of those amines which possessed ammoniacal characteristics to a very feeble extent.

142. Interaction of sulphur monochloride with organic compounds containing the reactive methylene ($-CH_2-$) group. Formation and properties of dithio-ketones



KUVERJI GOSAI NAIK *and* VASHVANT NARAYAN BHAT, Baroda.

The work described is a continuation of the work published before (Naik. J. 1921, *119*, 379–385., 1921, *119*, 1231-1242). The interactions of sulphur monochloride with (1) malon-di-ethylamide, (2) malon-di-*n*-propylamide, (3) malon-di-*iso*butylamide, (4) malon-di-*n*-heptylamide, (5) malon-di-*m*-tolylamide, (6) methymalon-di-*m*-tolylamide, and (7) methyl-malon-dibenzylamide, were examined. Of these (4), (5), (6) and 7 were prepared for the first time, by heating a mixture of the corresponding ester and the amine in the proportion of 1, 2 molecules either in a flask or in a sealed tube, and separating the products. Whereas, compounds (1), (2), (3), (4) and (5) interacted to give dithioketones of the general formula  compounds (6) and (7) gave dithioethers of the general formula 

It has been found that on nitration with fuming nitric acid, the dithio-grouping remains intact, the nitro-groups entering only the aromatic nuclei. Whereas sulphur monocholoride appears to possess the constitution  when it interacts with ethylene to produce mustard gas, the reactions studied so far show that sulphur monochloride has the constitution  . It seems that sulphur monochloride interacts in the above two forms under different circumstances.

143. Influence of light on certain catalytic reactions.

NAGENDRA CHANDRA NAG, Calcutta.

Bubbler method of observation and graphic method of recording by electro-magnetic writers as in the Photosynthetic Recorder described in Sir J. C. Bose's "Ascent of Sap" and more fully in his "Physiology of Photosynthesis" can be utilised in a variety of ways for the study of reaction velocity where gas is evolved.

In the present preliminary note, records of reaction velocity of certain catalytic agents, where oxygen is evolved, have been studied. The results observed prove, as expected, that the induced change of rate depends on (1) the state of dilution and (2) temperature.

In addition to the above a very remarkable modifying factor was discovered namely (3) light.

Several reaction chambers have been used side by side under controllable and comparable conditions, and simultaneous records have been taken. The apparatus has been so adapted that a series of records may be obtained free from manipulation by the observer.

Section of Zoology.

President:—R. B. Seymour Sewell

Presidential Address.

The Study of Zoology in India in the Future.

Ladies and Gentlemen,

My first duty towards you is to thank you for the honour that you have conferred upon me in electing me president of this Section. I feel that this honour has been conferred by you upon me more because of the position that I hold, as Director of the Zoological Survey of India, than for any outstanding merit that I can lay claim to in the sphere of Zoology. In consequence of the exigencies of my former appointment, namely that of Surgeon-Naturalist to the Marine Survey of India, I have but rarely been able to attend these annual meetings of the Indian Science Congress and it therefore gives me particular pleasure to be here to-day and to be able to make your acquaintance in the capacity of your President.

It is the custom in this Congress that the Presidents of the various sections should deliver a Presidential Address, dealing with some aspect of the subject, with which the Section deals, that is of interest and importance to all those who are members of the Section; and I have found the choice of a subject for my address to you to-day a matter of some difficulty. In most cases an address such as this consists of a review of the work done or of advances in our knowledge made during the past year or series of years. Some of you, however, may remember that in his Presidential address to this Section in 1921, Dr. Gravely, of the Madras Museum, gave an admirable review of the history of Zoological research in India in the past, and as recently as 1923 Dr. G. Matthai, of Lahore University, chose as the subject of his address that branch of Zoology that for many years has been my particular study, namely Oceanographic Research in Indian Waters. It is true that he limited his summary to the period prior to the outbreak of war in 1914 and that during the last few years considerable work has been carried out, especially on board the R.I.M.S. *Investigator*, that has resulted in, I think I may justly claim, a not insignificant contribution to our knowledge; but to deal in my Presidential address to you to-day with this branch of research would inevitably result in my address becoming in the main a summary of my own work, some of the results of which have already been published and the remainder will, I hope, before long appear in print in the

"Memoirs of the Asiatic Society of Bengal." The results obtained will thus shortly be available to you all *in extenso*; and a summary and discussion of them now would be merely to anticipate what I shall hope to tell you later. Moreover, an outline or summary of any one branch of zoological research can, of necessity, only have any very great interest for and appeal to comparatively few, namely to those who may be for one reason or other interested in that particular branch of learning or who may be engaged in research of a cognate nature; and I feel that a Presidential address should deal with some aspect of zoological work that has a profound interest for you all. Now there is one topic that is of the very greatest importance to us, whether our interest in Zoology is confined to the research side or to the academic branch, and this is the very vital question of the study of Zoology in India, not in the past, but in the future. To-day I propose to direct your attention to this most important problem, a problem that is so important and is so vast that it will inevitably affect, not only us trained zoologists or those who in the future may take up the study of Zoology as a profession and as their life's work; it is a subject that will eventually affect the whole of this vast country from end to end, although the application of Zoology to the every day needs of the population of this country is at present in its infancy and the importance of a knowledge of Zoology has hitherto been but little realized.

Zoology can roughly be divided, like the territory of ancient Gaul, into three parts. The first of these is Taxonomy and Morphology, and along with these goes the study of zoological Physiology, for, as you know, the physiology of an animal is often as specific in its character as is the actual structure. The second branch of Zoology is the study of Embryology and Genetics; and the third great line of study is that of Ecology and Bionomics. In my opinion it is this third branch that is the greatest of the three; but its study can only successfully follow on a correct taxonomy. The first essential then of zoology is a study of Taxonomy; and in order to form a true estimate of the position of any species in our scheme of classification of the animal kingdom, taxonomy must be combined with the study of embryology and morphology and in certain cases, and possibly far more often than has been the case in the past, with the study of the animal's physiology and bio-chemistry. Now it is in this sphere of taxonomic research that the Zoological Survey of India both can be and is only too willing to be of assistance to every zoologist throughout the whole of India. It has been whispered to me that certain zoologists in this country, though I hope that none such are present among you to-day, hold, or at least held, the opinion that the Zoological Survey of India is jealous of other zoological institutions. I would beg you, if any of you still retain this belief, to rid your

minds of it once and for all. We are, and I speak for my colleagues just as much as for myself, not only willing but desirous of doing all that we can to help the *bona fide* students of Zoology in this country and to improve as far as lies within our power, the various institutions that have grown up and, I am glad to see, are still growing up in India. The facilities that we can at the present time offer to research workers in our laboratories in Calcutta are limited; but I have room for at least six research workers, for four zoologists and two anthropologists, and I should like to see these places occupied the whole year round. The number of my colleagues in the Survey is but small and it is, therefore, only in certain groups of animals that we are at present able to assist research-workers directly by identifying for them specimens that they may have collected; but the Zoological Survey of India is in a position to be able to arrange with experts, not only in India but all over the world, for the identification of any animal that may be sent to us; and in this way we can honestly claim that we are both able and willing to give very material assistance. The study of Taxonomy will, as the fauna of this country, become more and more known, cease, sooner or later, to have any very great attraction for the research-worker; at the present time most of us have willy nilly to become taxonomists, since in almost every group of animals that we may wish to study our knowledge of the various species is still meagre; but I would impress on you that the study of this particular branch should never be considered an end in itself. It should be regarded merely as the necessary preparation for wider, more interesting and frequently more important studies.

The study of Morphology and Comparative Anatomy in this country is in its infancy. As some of you may know there have from time to time appeared in the "Records of the Indian Museum" papers dealing with this branch of study and I am glad to see that there is in existence in India a movement for the production by what I may term a Committee of Professors in the various Colleges of a series of monographs dealing with the detailed structure of some of the commoner and most typical animals in the various phyla, though the idea underlying the inception of this series appears to have been the necessity of having standard works for the purpose of teaching rather than any special interest that the members of this committee took in the subject. In England and Europe, as well as in America, the study of Morphology appears to be at the present time out of fashion, and its place in zoological research has been taken to a great extent by the study of Genetics; a movement that in England can be traced very largely to the influence and enthusiasm of the late Professor Bateson. The study of Genetics is, doubtless, important and it is, apparently, regarded as of particular importance by those who are engaged

in such researches; indeed, these enthusiasts go so far as to suggest, if not actually to state in so many words, that they and they only are real zoologists. But it appears to me, though I may be underrating the full importance of the subject, that this branch of research, at any rate as it is conducted at the present time, can only serve to explain the mechanism of the inheritance of 'discontinuous variation,' and no results, however startling they may appear to be, can explain the mechanism of the inheritance of 'continuous variation,' which, as most, if not all, field naturalists are convinced, is the main line along which the evolution of the animal kingdom has taken and still is taking place.

In India, as I have already remarked, we are still in the stage in which Taxonomy must be our first line of research; but what of the future? Is there any reason why we in this country should adopt the outlook or the fashion, as regards research, of any or every other country? We have in India our own fauna and our own problems and I would like to see Indians building up their own type of Zoology and of zoological research-worker. My own outlook has, doubtless, been largely influenced by and is the outcome of my experience as Surgeon-Naturalist on the "*Investigator*," and I would put before you to-day a very strong plea for the field worker and would impress upon you the paramount importance to this country of the study of Ecology and Bionomics. When once we have succeeded in identifying the various composite factors in the fauna of any given area, the next step in our line of research should take us out of the laboratory into the open country. We must go out and study the animals in their own surroundings; and not only should we do so ourselves but we must encourage our students to do likewise. If we do this we shall at once find that the interest our students take in their studies will be increased tenfold. Dr. Gravely recently told me of his experience when he took a party of students from the Madras University down to Krusadai Island in the Gulf of Mannar, where there is a small field laboratory (it cannot, as yet, be said to be a Marine Biological Station, for it has no permanent equipment; but it serves an important purpose as a site where the study of marine animals in their natural surroundings can be carried out); as soon as these students found themselves able to observe the living animals in the open, in contrast to the study of preserved organisms in the laboratory, they exclaimed, "Oh, Sir, we did not know that Zoology could be so interesting." The study of the animal in its natural habitat is more than interesting, it is fascinating; and it is along these lines that zoologists not only can and will find the most interesting work, it is on these lines that they can help to raise Zoology to the ideal position to which it may in the future attain, of being the greatest philanthropic agent

in the world. Zoology has up to the present time been all too rarely called upon to assist in the solution of some of the greatest problems that confront us in India, whether we are concerned with the food supply of the millions of inhabitants or with their health and disease. In other countries the absolute necessity of carrying out systematic investigations regarding the Ecology and Bionomics of the marine fauna has resulted in the establishment of numerous Marine Biological Stations and the appointment of a large staff of marine biologists. Even in the little island of Ceylon this necessity has been recognised and the work carried out under the Ceylon Government has resulted in the formation of a company to exploit, by means of sea-going trawlers, the fish supply of the Ceylon and of our Indian coasts. In India the maintenance and improvement of our fish supplies, whether from the coast or from inland waters, or even the improvement of our cattle, under the direction of the Veterinary Departments, are all problems in Zoology and can only be solved by the application of zoological research and zoological methods. Similarly the medical research worker may, as a result of his studies in laboratories and hospitals, be able to incriminate certain animals as the carriers of disease ; but from that stage on the eradication of the disease from the country becomes a problem in field Zoology, and I am convinced that, though we may know that the *Anopheles* Mosquito can transmit Malaria and the Sand-fly Kala-Azar, it is only by the application of biological methods that we shall ever succeed in controlling and eradicating these pests and in freeing the population of India from two of the great curses under which we at present suffer ; and the same may be said of many of the diseases of plants that affect the food supply.

There are, I admit, difficulties in the way of carrying out such field researches as I have indicated and the greatest of these is finance—or rather the lack of it. But I believe that if the matter is sufficiently strongly urged by us, one and all, the Authorities of the various Institutions, to which we belong, can and will be ready to meet our requirements in this line, as far as they are able ; and here we have another line of assistance that we in the Zoological Survey of India can render. The officers of the Survey can and will, I am sure, be willing to take with them when they go out on tour one or two selected students from the Colleges and Universities ; in this way these students would, at a comparatively small cost, be able to study the fauna of this country in its natural surroundings and would further have the benefit of the experience of a trained field-worker.

Now the moment that we commence our studies of the Ecology and Bionomics of the fauna of this country we discover that we need a far wider knowledge than that of zoology alone. To quote from the late Dr. Annandale, " Zoology is so closely connected with other branches of

biology and so dependent in the last resort on Geology, Chemistry, Physics and Mathematics that in my own work I find it frequently necessary to apply to members of other Departments for special information. My experience has been that such information is always given in a most ungrudging and generous spirit, when applied for personally." I can most emphatically corroborate this statement ; but are we zoologists justified in continually demanding from others that they should undertake on our behalf researches that we ought to be in a position to carry out for ourselves ? We must remember that they have their own interests and their own studies, and that every time they so kindly undertake to assist us, they have to give up time, which they value every bit as much as we do, in order to carry out some piece of research work that has little or no interest for them. To the field-zoologist or naturalist it is of the greatest importance that he should be able to investigate, not only the fauna, but the associated flora, the chemical composition, the hydrogen-ion concentration and the amount of oxygen and carbon dioxide gases present in the soil or water, in which the animals that he is studying, live ; for every one of these factors has a most profound bearing on the animal life and, furthermore, every one of these factors is continually changing with the change of the seasons. In certain cases we do undoubtedly require a knowledge that we ourselves are not in a position to obtain. The late Dr. Annandale, in one of the last papers that he published, showed to how great an extent the character of the Mollusc inhabitants of any given area of water depends on the amount of lime-salts present ; it is, therefore, of the utmost importance to us that we should know the chemical composition of the water, and here we certainly require the services of a trained chemist, for it is beyond the scope of work of a zoologist to carry out elaborate analyses of a highly technical character, and, moreover, these analyses must be conducted repeatedly throughout the different seasons of the year, for it has clearly been shown that in such large rivers as the Nile in Egypt and the Ganges in this country there is an actual chemical change in the composition of the water, following and dependent on the change from the dry to the rainy season. Dr. Hora's studies of the inhabitants of the hill streams of India has equally shown the manner in which the surroundings can mechanically influence the structure of the various animal inhabitants, whether they be Fish, Amphibia or Insects. For those of us whose researches lie in the sea the problem will, I have no doubt, prove to be just as complicated. In European and Temperate seas there is undoubtedly a very considerable seasonal variation in the chemical composition of the water, that affects the amount of silicates and phosphates present in solution, and this variation can be traced directly to the

Fauna and Flora and *vice versa* changes in the Fauna and Flora are due to the alteration in the chemical composition. Almost certainly similar changes are going on in the waters of the Indian seas and sooner or latter we must attempt to elucidate these changes. At first sight then it appears to be essential that we should at the least have the assistance of both a botanist and a chemist to assist us and here I may take the opportunity of impressing on you the great advantage that can be derived from team-work, and such collaboration should be particularly easy to attain in your Colleges and Universities, where Zoology and Botany, as well as Chemistry, are being taught side by side. But failing such collaboration, there is a very great deal that a zoologist can do and should be able to do for himself. The study of the hydrogen-ion concentration, the amount of dissolved gases and the salinity of the sea-water requires but little technical knowledge, for the methods of estimation have now a days been so simplified and standardised that we can with very little experience carry out our own investigations, provided that we possess the necessary apparatus. Every student should be taught in your advanced classes to estimate the hydrogen-ion concentration of both soil and water and every student of our marine fauna should be able to carry out titration with silver nitrate solution and so estimate for himself the degree of salinity of the sea ; this latter process has been most carefully standardised by the " Conseil Permanent pour l'Exploration de la Mer " and the technique is one that is easily learned ; every observation on our marine fauna should, therefore, be accompanied by observations on the temperature and salinity of the sea-water itself.

As one gains wider experience one finds, however, that our researches must be carried even further afield ; let me cite a couple of examples. During the past year I have had occasion to investigate an epidemic of mortality among the fauna of the tank in the compound of the Indian Museum. On the morning of the 17th of February last it was discovered that many of the fish in the tank were dying with all the symptoms of asphyxia ; nor were the fish the only inhabitants that were affected. In varying degrees it was found that both the Molluscs and the Crustacea were also suffering from the same condition. It is probably well known to you that at about this season of the year, that is to say from March to June, there is annually a very heavy mortality in the tank fauna throughout India ; Annandale noticed the occurrence of this phenomenon, and called attention to it, particularly among the Sponges and Polyzoa, and I have myself called attention to it in the Mollusca. Annandale put forward the view that this mortality was due to imperfect acclimatisation, the animals being unable to withstand the high temperatures that prevail during the dry season of the year. In view, however, of the wide distribution

and the continued survival of the fauna in spite of this mortality, this conclusion can, I think, hardly be justified and we must look for some other cause of it. One of the problems that I had to consider when dealing with the mortality in the Museum tank was, whether this mortality was merely a part of this annual phase or was it due to a local specific cause ? An examination of the water, that was carried out for me by the Chemical Examiner to the Government of Bengal, showed that no known poison had been introduced into the tank. Further examination showed that there was no reason to think that the hydrogen-ion concentration was abnormal, though it must be owned that our knowledge of the changes in this feature during the course of the year is practically *nil*. An examination of the dissolved gases revealed that the amount of oxygen in the water was, although somewhat less than that usually present in other countries, not so greatly diminished as to be actually harmful ; the carbon dioxide present in solution was however, abnormally great in amount and it seemed certain that this was the actual cause of death. I was then faced with another problem, namely, what was the cause of this great increase in the amount of the carbon dioxide ? A careful study of all the known data revealed that it was almost certainly attributable to the meteorological conditions that were at the time, and had been for some days previously, prevailing over Calcutta. During a short period prior to the outbreak the air temperature had been steadily rising ; and not only was the maximum temperature some degrees above normal, but so also was the minimum temperature, and this condition of affairs reached its climax on the day prior to the epidemic. At the same time there had been no rainfall ; there had been a steady rise in the humidity of the atmosphere, and an almost complete absence of wind. The result of these combined meteorological conditions had been to completely inhibit the normal circulation in the tank, on which the oxygenation of the water and the removal from it of the excess carbon dioxide very largely depends ; there was no "change over" between the surface and the bottom waters, since all surface currents due to wind had ceased, nor was there any change due to convection currents, since the raised temperature of the water, combined with the increased humidity of the air and the consequent decrease in the rate of evaporation, had prevented the surface layer becoming more dense than the underlying stratum. There had thus been a complete stagnation of the water in the tank, and a consequent increase in the amount of carbon dioxide, especially in the lower levels, till it had reached a lethal concentration and so had poisoned the inhabitants. It is clear then that, at any rate in this instance, the ultimate cause of the mortality of the fauna of the tank must be laid at the door of the meteorological conditions and it seems not improbable

that the annual mortality, to which I have referred above, is to be attributed to the same cause.

I have found that the study of the meteorological conditions is equally essential in any investigations into the conditions under which the marine fauna lives in Indian seas. As a result of several years' work regarding the conditions of the surface water throughout the whole width of Indian seas from the Maldive Islands on the west to the coast of Burma on the east I have found that continual changes are taking place, especially as regards the salinity. In addition to the seasonal changes, that are due to the alternation of the wet and dry seasons and the effects of the two monsoons, there is evidence that long period oscillations, of the nature of "seiches" the time-period depending on the size and shape of the sea basin and the salinity of the sea-water, are, at any rate at certain seasons of the year, present in the deeper layers of the ocean and that these are continually bringing up, from considerable depths to near the surface, masses of water that have a higher salinity than the normal surface water. These long period oscillations in the surface salinity have time-periods of approximately 28 days in the Arabian Sea, 10 days in the Laccadive Sea, 15 to 16 days in the Bay of Bengal, in which the type of "Seiche" appears to be a bi-nodal one, 18 to 19 days in the Andaman Sea and $2\frac{1}{2}$ days in the Gulf of Mannar. These oscillations in the surface salinity correspond to a to-and-fro swing in the long axis of the basin, and in addition I have found evidence of a transverse seiche, also bi-nodal in character, across the Bay of Bengal, having a time period of $5\frac{1}{2}$ days. At the culminating phase of each swing there is a mixture of surface water with deeper and more saline water and this causes a rise in the salinity of the surface water itself that has a profound effect on the fauna. Corresponding to the rise and fall of salinity we get the appearance on the surface of shoals of organisms, sometimes of one kind and sometimes of another; in some instances the shoal consists almost entirely of Salps, in others of small Crustacea, such as *Lucifer*, while in yet others we get enormous numbers of a large Rhizostomous Medusa. Superposed on these long period oscillations of salinity we get a double diurnal oscillation in the salinity, that also appears to be brought about by an upwelling from some depth below the surface, probably from as great a depth as 50 to 100 fathoms, of water that is usually more saline than the surface water itself; and, accompanying this double oscillation in the salinity during the course of the day, I find that there is evidence pointing to very definite changes in the plancton of the surface levels. Many of you are doubtless familiar with the so-called "vertical migration" of the plancton, that has been shown to occur in European waters and in other Temperate seas, a migration that is usually attributed to the activity of these

minute animals themselves. Personally I am profoundly sceptical regarding the possibility of these small organisms being able to make their way, in the time available, through the immense columns of water between the levels from and to which they are said to migrate, in some cases as much as 200 fathoms. In Indian waters, so far as my experience goes, this alteration of level, at which the planctonic organisms occur, appears to take place, not as in temperate waters at periods corresponding to day and night, but twice a day at times that correspond roughly to the changes in the barometric pressure. In the case of the small Crustacea and especially the Copepoda, small crustacean larvae, *Sagitta* and similar small animals we get their appearance on the surface in large numbers at about 10 a.m. and again at 5 to 6 in the evening, while there is a marked diminution in their numbers or even a complete absence at 1 to 2 p.m.

This appearance and disappearance of these organisms shows little or no relationship to the rise and fall of the tide but appears to agree with the times of upwelling of the water from the deeper strata. Now the ultimate causation of this oscillation in the sea water in the case of both the long-period "seiche" and the diurnal upwelling is to be found in the meteorological conditions that prevail over the open waters With each succeeding monsoon there is an alternation in the direction of the wind ; during the south-west monsoon the wind blows steadily towards the north-east and during the north-east monsoon it blows in exactly the opposite direction ; in consequence of this alternation the surface waters are piled up first on one side of the various basins and then on the other, and as soon as the wind ceases the water tends to flow back to its proper level and thus the to-and-fro swing of the deeper stratum is set in motion. Similarly, during each twenty-four hours the rise and fall of the barometer is accompanied by a fall and rise of the strength of the wind, in consequence of which the surface water at the times of low barometric pressure is blown away and water from below wells up to the surface to take its place. We thus have large masses of water constantly in a state of movement and with each period of upwelling, planctonic organisms from below make their appearance on the surface only to disappear again as the wind drops and the deeper stratum again sinks back to its normal level. In Indian waters it seems highly probable then, that the "migration" of the plancton is in reality, at any rate in the main, a "translation" and is not an active process.

I think I need go no further in emphasising the extreme importance, therefore, of carrying our researches far beyond the hard and fast limits of strict zoology ; and it is clear that, in order to complete our investigations regarding the Indian Fauna we must, each one of us, take a wide view and carry on re-

searches simultaneously into the fauna and the general conditions under which it lives, even to the extent of taking observations on meteorology. Whether in the future such researches will be carried out, and it is only such researches that should be considered adequate, will depend on you who are listening to me to-day. It behoves us, therefore, to pause for a moment and consider what is to come in the future; and I ask you the age-long question "Quo vadis?", for it is to you, the Professors, Lecturers, Demonstrators and Advanced Students of Zoology in our Universities and Colleges throughout India, that we must look for an answer. The teaching of Zoology throughout this country now rests absolutely in the hands of you Indians yourselves; in most, if not in all, the numerous colleges there is a department of zoology, more or less well equipped and with an ever-increasing number of students; and I ask you "what type of trained zoologist are you turning out?" Are your students being trained by you in the broadest principles of zoology such as I have indicated? As the late Dr. Annandale remarked before this section of the Indian Science Congress in 1922, "Applied zoology should be and perhaps some day may become the great philanthropic agent of the world"; but this great ideal will never be attained in this country unless your students are learning at your hands an enthusiasm for their subject that will enable them throughout their whole life to devote themselves whole-heartedly to its study. Only by so doing can you and they hope to raise Zoology to the high level at which we all wish to see it.

Abstracts of Papers.

1. *Tetrachilomastix bengalensis* Chatterjee, a different species or the same as *Chilomastix mesnili* Wenyon.

G. C. Chatterjee, Harendra Nath Roy *and* Amulya Nath Mitra, Lahore.

In this paper the authors have decidedly shown that *T. bengalensis* is quite different from *C. mesnili* and that four anteriorly directed flagella in *T. bengalensis* is not an artifact as remarked by Wenyon in a private communication to one of the authors. The anatomy of the flagellates has been studied in detail.

2. An account of the intestinal Flagellates.

Harendra Nath Roy, Calcutta.

The author is engaged in studying the intestinal Flagellates since 1923 and has given an account of the flagellates he came across in 3 years. The materials for study were obtained from 230 animals. Of these, five were human cases, the rest were lower animals. Altogether 17 different species have been described. Two of these are for the first time described by the author—*Cryptobia serpentis*, n. sp. from the gut of a Russel's viper and *Embadomonas ranae*, n. sp. from the gut of frogs. The morphology of all the parasites has been studied in detail and successful cultures have been obtained with six of these micro-organisms. The multiplication of some of these organisms has also been studied.

3. On some parasitic Ciliates from Indian frogs, toads, earthworms and cockroaches.

B. L. Bhatia *and* A. N. Gulati, Lahore.

A large number of Ciliates belonging to the families Opalinidae, Anoplophryidae and Bursaridae are reported and described from the alimentary canal of the hosts examined.

Gatenby and King have recently revived the claim of *Opalina* to be regarded as a flagellate. The authors of the present paper are unable to subscribe to this view.

Metcalf, in his exhaustive monograph on Opalinids, thinks it unfortunate that Indian Anura have been so little explored. Three new species of *Cepedea*, viz; *C. metcalfi*, *C. punjabensis*, and *C. sialkoti* are described from two species of *Bufo*. *Opalina* is represented by *O. coracoidea* subspecies *lahoriensis*, *O. ranarum* and *O. lata*.

Haupasella nova Cepede is reported from *Pheretima posthuma* and *P. hawayana*.

Balantidium duodeni, *B. helenae*, *B. elongatum*, *B. gracile*, *B. bicavata* (sp. nov.) and *B. amygdalli* (sp. nov.) are described from various frogs and toads. *B. hyalinum*, described by Dobell from Ceylon, is identical with *B. duodeni* St., and his *B. ovale* the same as *B. helenae* Bezz. The re-introduction of the generic title of *Balantidiopsis* by Ghosh is considered unnecessary.

The genus *Nyctotherus* is represented by *N. macropharyngeus*, *N. cordiformis*, *N. reniformis* (sp. nov.), and *N. ovalis*.

4. Four new species of *Epistylis* Ehr.

Ekendranath Ghosh, Calcutta.

Three species, *E. vasiforme*, *E. conica* and *E. subconica* are from the ponds of Calcutta, and *E. subvasiforme* from Midnapur town. *E. conica* and *E. subconica* are very common. *E. vasiforme* differs from the known species by its conical and vasiform shape, the contracted body being ovate to pyriform with an anterior nipple plicate longitudinally with annular folds at both ends and by numerous animals on the stalk. The vestibule is very long. *E. conica* is characterized by a conical body, slightly gibbous on one side and, when contracted, pyriform with annulations posteriorly, by the peristomial margin being slightly everted and by the vestibule short and wide. There are numerous individuals. *E. subconica* is conical-campanulate in shape and, when contracted, pyriform with anterior end slightly depressed and puckered radially. The peristomial margin is vertical and slightly everted. The vestibule is short, tubular and curved. Few individuals. *E. subvasiforme* has a vase-shaped body with raised peristomial margin and wide short vestibule. Numerous individuals in a colony.

5. Some further observations on the Monocystids of the Oligochaetes and Polychaetes.

S. B. Setna, Bombay.

This paper is in continuation of the one read at the Indian Science Congress, Bombay, 1925.

Hesse in 1909 published a monograph on the subject and included therein all the species of Monocystids discovered up to that time in the different species of earthworms. In India so far very few worms have been examined for Monocystids. The author has examined a number of worms from Darjeeling, Calcutta, Madras, and Bombay. He has discovered several interesting forms from the seminal vesicles and the coelom of various worms and the description of the several species have been recorded in the paper; the most remarkable is a species of *Nematocystis* with four spines at either of its ends from the coelom of *Pheritima* sp.

Besides these, *Monocystis mitis* Leidy, described and figured as long ago as 1882 from the intestine of an Oligochaete. *Distichopus silvestris* Leidy has been recorded again from the intestine of a Polychaete, *Amphitrite* sp. The various stages in the life cycle have also been met with. *M. mitis* is referred to the genus *Nematocystis*.

6. On some fresh-water Rhizopods and Flagellates from Kashmir.

B. L. Bhatia, Lahore.

Fresh-water Protozoan forms are cosmopolitan in their distribution, and the forms met with in India are not very different from those known from European countries. Still our knowledge of the occurrence of various Protozoan forms in different parts of India is very inadequate, and a survey of the fauna is necessary. A description of the fresh-water Ciliates from Kashmir was presented at a former session of the Science Congress. A list of Rhizopods and Flagellates, with brief notes on them is given in this paper.

7. Parasitism among Protozoa.

B. L. Bhatia, Lahore.

Evolution of Parasitism. Specificity and non-specificity of hosts. On looking through the complete lists of Polycystid gregarines (Watson—

Kam), Monocystid gregarines (compiled by myself), Opalinid ciliates (Metcalf) and other more highly organised ciliates like *Nyctotherus* and *Balantidium* (compiled by myself), it is found that the majority of these gregarine and ciliate parasites are confined to a single host. Conclusions to be drawn from such data.

Remarkable speculations of Metcalf regarding distribution of Anura based on the occurrence of different genera and species of Opalinids. Do these speculations get any support from such data as are available concerning the occurrence of the more highly evolved coprozoic ciliates in the same hosts ?

Bearing of data from Monocystid parasites on Stephenson's speculations regarding the geographical distribution and genetic relationship of Earthworms.

8. Preliminary notes on *Ctenoplana indica* n. sp.

Prof. K. Ramunni Menon, Madras.

The author records certain observations, mainly on the external features and habits, which he has made on a new species of *Ctenoplana* which he has obtained at Madras.

9. On the systematic position of the Actiniarian genus *Ixalactis*.

Prof. K. Ramunni Menon, Madras.

The genus *Ixalactis* is at present placed in the family Actiniidae in the tribe Actiniina. The author brings forward evidence to show that the genus, if it is to be maintained as a seperate genus at all, should be placed in the tribe Stichodactylina.

10. A note on the *Hydra* of the Bombay Island.

P. R. Awati, Bombay.

While collecting material for teaching purposes, a few specimens of *Hydra* with four tentacles were found. On making inquiries of the local Biologists it was ascertained that none of them had come across such specimens of *Hydra*, their specimens having five, six or eight tentacles.

According to Annandale (Fauna of British India, Vol. Fresh water Sponges, etc.) the four-tentacled specimens of *Hydra* form the summer brood of *H. vulgaris* of Calcutta. He further says: "There is evidence, however, that in those parts of India which enjoy a more uniform climate than Lower Bengal, polyps found at all times of the year resemble those found in the hot weather in Calcutta and sometimes produce spermatozoa or eggs."

The specimens of the Bombay Hydra are monoecious, while the sexes of *H. orientalis*, which is the tropical phase of *H. vulgaris*, are invariably distinct. It seems therefore probable that the Bombay *Hydra* belongs to a different species. Further observations are being made to settle this point.

11. Some Jelly-fishes of the Indian seas.

H. S. Rao, Calcutta.

Of the Coelenterate fauna of the Indian coasts and surrounding seas the Scyphomedusae are one of the least known groups. A preliminary account is given of the Scyphomedusae from the coasts of India and the adjoining seas collected at various times and accumulated in the collection of the Zoological Survey of India.

12. Three new Trematodes from reptiles.

G. D. Bhalerao, Nagpur.

The author has described in this paper a new species of trematode from *Mabuia dissimilis*, a new species belonging to a new genus of the family Echinostomidae from *Uromastix hardwickii*, and the third new species belonging to a new genus and a new sub-family of the family Paramphistomidae from *Batagur baska*. While propounding a new species, a new genus or a new sub-family the arguments for so doing are offered.

Mesocoelium meggitti n. sp.—Numerous specimens of this species were obtained at Rangoon from the intestine of *Mabuia dissimilis*. It has the following specific diagnosis :—Body broad anteriorly and tapering posteriorly. Cuticle beset with spines. The ratio of the suckers 2 : 3. Intestinal caeca extending from 1/2 to 7/11 of the total length of the body. Testes symmetrical at the sides of ventral sucker, the right slightly in advance. Cirrus-sac not reaching ventral sucker. Ovary on the right side of the middle line. The extent of vitellaria varying. Receptaculum seminis close to ovary. Eggs 0·034–0·37 × 0·023–0·026 mm.

Testisaculus indicus n.g., n.sp.—About twenty-five specimens of this species were obtained from the intestine of *Uromastix hardwickii*. The species could not be fitted in any of the genera of the family Echinostomidae so a new genus had to be created to accommodate it with the following diagnosis :—Body middle-sized. Cuticle anteriorly covered with spines. Collar spines in two dorsally unbroken rows, differentiated into "Eckstachelen" and "Randstachelen." Testes deeply lobed. Spermsac present. Cirrus-sac extending beyond ventral sucker. Vitellaria extending from the posterior end of the body to the posterior border of ventral sucker and meeting centrally behind testes. Excretory bladder Y-shaped. Ovary anterior to testes. Genital pore between the ventral sucker and the intestinal fork. Receptaculum seminis and Laurer's canal present. Uterus small. Eggs few, operculated.

The specific diagnosis is also given.

Stunkardia dilymphosa n.g., n.sp. Only two specimens of this species were obtained at Rangoon from the rectum of *Batagur baska*. This species belongs to a new genus which can not be accommodated in any of the existing sub-families of the family Paramphistomidae, so it was thought desirable to create a new subfamily for its reception, with the following diagnosis :—Paramphistomidae : Body middle-sized. Oral sucker with two diverticula. Ventral sucker with two posterior lips. Excretory bladder small, with canals coiling round the intestinal caeca. Two pairs of lymph canals : one dorsal and one ventral. Cirrus-sac absent. Uterus with very few eggs. Parasites of Reptiles.

The diagnosis of the genus is also given. The name of the sub-family proposed being Stunkardinae.

13. The Trematode Parasites of a Burmese house-crow, *Corvus insolens*.

G. D. Bhalerao, Nagpur.

In this paper the author has described four new species of digenetic trematodes, the abnormal form of *Echinochasmus corvus* n.sp. and has recorded *Platynosomum acuminatum* Nicoll, 1915, from the Burmese house-crow, *Corvus insolens*, dissected at Rangoon.

Echinochasmus corvus n.sp : This species is abundantly found in the intestine and has got the following specific diagnosis : Body broad behind and tapering anteriorly. Cuticle with spines as far as the posterior border of the testes. Head-collar with 24 spines : 3 + 3 "Eckstachelen" and 9 + 9 "Randstachelen." Ratio of oral to ventral sucker 1 : 2. Vitellaria not reaching pharynx anteriorly. Testes in posterior part, entire. Eggs 0·07—0·085 × 0·045—0·06 mm.

The abnormal form of *Echinochasmus corvus* n.sp. : From among the mass of specimens of this species one is found to show very interesting deviations from the type specimen. There is only one testis found in the posterior part of the body. The intestinal caecum on the right reaches only as far as the centre of the ovary. The vitellaria on the right extends anteriorly only as far as the level of the ovary.

Stephanoprora reynoldi n.sp. : Only one specimen of this species was obtained from the intestine. Its specific diagnosis is as follows : Body elongated. Cuticular spines disappearing at the posterior margin of the anterior testis. Head-collar with 22 spines : 4 "Eckstachelen" and 18 "randstachelen." The "Echstachelen" opposite the "Randstachelen." Testes in mid-body. Cirrus-sac extending to the posterior border of the ventral sucker, situated on the left. Vitellaria extend anteriorly to the centre of the anterior testis. Eggs 0·056—0·089 × 0·031—0·049 mm.

Phaneropsolus insolens n.sp. : On one occasion forty specimens of this species were obtained from the intestine. It has the following specific diagnosis : Body pear-shaped, covered with spines. Oral sucker bigger than ventral. Intestinal caeca passing posteriorly to the level of the anterior border of the ventral sucker. Testes postero-lateral to ventral sucker. Cirrus-sac not extending anterior to intestinal fork. Genital pore anterior to ventral sucker, to the left of the central line. Ovary to the right of ventral sucker. Vitellaria lateral to intestinal caeca. Eggs 0·06—0·07 × 0·04—0·05 mm.

Lyperosomum kakea n.sp. : Sixteen specimens of this species were obtained on one occasion from the liver. Its specific diagnosis is as given below : Body elongated, tapering at both ends, broadest at the level of ventral sucker. Ventral larger than oral sucker. Testes oval, one behind the other, somewhat posterior to ventral sucker, their long axis being oblique to the length of the body. Ovary behind testes, its long axis being transverse. Cirrus-sac ends some distance anterior to testes. Genital pore near pharynx. Vitellaria a short distance behind ovary. Eggs 0·028—0·03 × 0·016—0·018 mm.

Platynosomum acuminatum Nicoll, 1915 : Only one specimen of this species was obtained from the liver along with sixteen specimens of *Lyperosomum kakea*. It agrees in most respects with *Platynosomum acuminatum* Nicoll, 1915. The only points of difference being the dimensions of the body and the vitellaria lying a short distance behind the testes.

In all cases of new species the discussion of their affinities with the existing species of the genus is offered.

14. Re-description of *Caryophyllaeus indicus*.

Prof. M. A. Moghe, Nagpur.

In 1925, the author described a cestode parasite *Caryophyllaeus indicus*, n.sp. from a siluroid fish *Clarius batrachus* Bl. Woodland (1926) suggests that the bodies described by me as "Post-ovarian vitellaria" are in reality ovarian follicles. Some new material was collected and re-examined.

Length from 15 to 29 mm. Maximum width, across the level of the cirrus pouch but anterior to cirrus-opening, is from 1·82 to 2·73 mm. The "head" in some specimens has numerous longitudinal furrows commencing anteriorly and continuing in the trunk for a short distance and in others commencing a little posteriorly resembling similar furrows described in *Lytocestus chalmersius* Woodland 1924, and *Monobothrioides cunningtoni* Fuhrmann and Baer 1926. Head is stumpy and bluntly rounded The musculature is similar to that described for *Lytocestus filiformia* Woodland (1923 and 1926) and consists of two layers of longitudinal muscle fibres (cortical and epimedullary) situated internal to the nuclear layer of the subcuticula. The vitellaria are cortical, i.e. situated between the

two layers of longitudinal muscle fibres. The genital apertures are situated in the last seventh of the body length. The aperture of the cirrus-sac is separate from the vagino-uterine aperture, the space between the two being approximately 220–270 μ. The vagina is a straight tube joining the uterus in the large shell-gland. The uterus has a sinuous course and lies on each side of the body. The anterior loop lies between the genital opening and does not extend anterior to cirrus-opening. Vitellaria do not extend behind this loop of the uterus.

The tests are medullary and are surrounded by vitellaria on dorsal and lateral sides. The ovary does not extend beyond the shell-gland and is made up of two masses of follicles—one on each side and an "isthmus." The follicles are cortical and the isthmus is medullary.

Eggs in balsam measure 80 μ by 40 μ.

Some remarks on the genera and relationship of the family Caryophyllaeidea are offered.

15. A preliminary Note on Helminth Parasites of *Ophiocephalus*. Trematodes and Cestodes.

S. C. Verma.

A short introduction is given.

A Trematode (*Derogenes*) is described from the stomach and gills of local species of *Ophiocephalus*.

An account is given of two Trematodes of the Genus *Clinostomum* from the body cavity of *O. punctatus*, and some interesting features noted.

The occurrence of an encysted and sometimes free but immature Trematode is discussed from *O. marulius*, and suggestion made as to its probable adult form.

A Cercaria (encysted larval Trematode) is mentioned from the pericardium and another from the liver of *O. punctatus*.

Descriptions are given of two Cestodes hitherto obtained from *O. marulius* and *O. punctatus*.

Two plates with figures of forms described are given.

16. Observations on a Pigeon heavily infested with Tape worms.

G. Sondhi, Calcutta.

One day the bird was noticed to be very much depressed. She stood moping in a corner and did not mix with other birds.

The wings were not held in the usual graceful manner, they were thrown down and hung at the sides. The tail instead of sticking out in a line with the dorsal surface of the body, was thrown down and rested on the ground.

The male bird came to her several times, caressed her, but the female showed no inclination for mating. The male bird finding no response on the part of his female mate went cooing after other female birds, but the sick bird seemed to take no notice of it. Now this was very unusual for this particular bird, as I knew her to be very fond of her male mate. Evidently the bird was very ill.

She ate very little but took plenty of water.

The bird was noticed to get worse day by day. The excreta were passed out very frequently and were mixed with large quantities of mucous, but there was no trace of blood in them. The excreta were not passed out in the usual clean healthy manner, a good part of them remained sticking to the feathers surrounding the cloaca. On the sixth day, I noticed fragments of tape worm proglottides in the droppings.

By this time the condition of the bird had become very poor. The pectoral muscles were greatly reduced in size and the keel of the sternum consequently looked very prominent.

The feathers were no longer neat and shining, they were ruffled and those surrounding the cloaca were very dirty and stuck together on account of the excreta adhering to them.

On the 7th day I was surprised to find some soaked wheat grains lying in the box in which the bird was kept for the night. I could not account for it then, but in the afternoon I saw the bird throwing out wheat grains that it had picked in the morning. This explained the mystery of the wheat grains in the box.

The same day the bird laid an egg with a very thin and crumpled shell. Next finding the bird in rather delicate condition, I took her to the Veterinary hospital where she was given two drops of extract of male fern. As a result the bird passed out several tape-worms and during the following days the symptoms gradually disappeared, and within two months the bird resumed her regular life.

The fact that the symptoms disappeared after the anthelmintic treatment suggest that the tape worms were the cause of the whole trouble.

17. *Acanthogyrus*, a new genus of Acanthocephalan worm, from the intestine of Labeo rohita.

G. S. Thapar.

Although a very extensive literature has been published in recent years on the Acanthocephala, very little work has been done in India on this group of parasitic worms. The writer, in the course of his investigations on the parasitic fauna of fishes in Lucknow, found a large number of specimens from the intestine of *Rohu*. These worms, on careful examination appear to belong to a new genus that has been given the name of *Acanthogyrus*.

The genus is interesting in the fact that it bears several rows (30–40) of spines encircling the body. The proboscis is armed with only three rows of large hooks, as is found in the genus *Feoechinorhynchus*. The lucunar system is very clear and has transversely running segmental commisures corresponding in position with the rows of body-spines, thereby giving the animal a distinctly segmental appearance.

The male genital organs have only two prostate glands and a Y-shaped ejaculatory duct.

The anatomy of this worm is described at length and concludes with a discussion on the systematic position of the genus in question.

18. On *Echinorhynchus* sp. from the common Crow (*Corvus corax* and *Corvus splendens*).

M. N. Datta, Allahabad.

The worms hang freely in the lumen from the wall of the small intestine.

Number, arrangement and shape of the spines is given.

Movements of the proboscis during attachment to the intestinal wall are peculiar.

The sexes are separate. Number of male specimens obtained is always less than that of females.

The anatomy and histology of the genitalia, body wall, nervous system and ligaments is described.

The ova choke up completely the body cavity, and the mode of their discharge through the oviduct is described.

In the male the prostate gland is large and consists of five lobes. The testes are also large and cover about one-fifth of the length of the body.

Various stages of sperm formation are clearly seen. Chromosomes are quite conspicuous. Similar stages in the development of ova have also been observed.

19. Observations on the reproduction of the Naididæ with certain facts of geographical distribution of the Indian Microdrili.

Prof. H. R. Mehra, Allahabad.

Aeolosoma kashyapi, *Ae. Viride*, *Aulophorus furcatus*, *A. michaelseni* and *Nais pectinata* were obtained from the Macpharson Lake, Allahabad in September, 1925. The last three species possessed sexual organs. A short account of their asexual reproduction is given. In January 1926 *Stylaria lacustris* with sexual organs were obtained. In March and April 1926 *Pristina longiseta*, *A. tonkinensis*, *Nais variabalis* and *Chaetogaster orientalis* developed sexual organs. A culture of the last species was kept for more than a month. The author maintains his previous conclusions about the appearance of sexual phase in the Naididæ.

An account of the genital organs is given. In *Chaetogaster orientalis* the germ cells arise in a diffused manner from the general body cavity.

Some interesting facts of the geographical distribution of the Indian Microdrili are given.

20. Suction of air by *Chaetogaster orientalis* as a means of locomotion.

Prof. H. R. Mehra, Allahabad.

A few distinct bubbles of air were observed in the crop and intestine of Chaetogaster orientalis. The mode of sucking air is described. The buoyancy is kept up by the air in the gut and the worms remain floating on the surface of water. The body can be moved by means of setae, which are used as oars. The arrangement of setae in a bundle helps in the movement. Such movements were observed in a large number of specimens for about a fortnight.

21. The reproductive processes of the Earthworm *Eutyphoeus waltoni*.

K. N. Bahl, Lucknow.

Unlike the process of conjugation in *Lumbricus*, the exchange of sperms in *Eutyphoeus* is direct and simple. During the act of copulation, two worms lie together in head to tail directions in such a way that the openings of the vasa deferentia of the one come to lie opposite to the openings of the spermathecae in the other and vice versa. The area of each spermathecal pore is raised into a papilla and correspondingly the region of the male pore shows a projecting penis with two penial setae in the centre of a circular depression. The penial setae and the penis are inserted into the spermathecal pore on the papilla and we get a "peg and socket joint" at two places in a conjugating pair. Numerous copulatory papillae keep the two worms adpressed against each other.

In July, August, and September these conjugating pairs have been seen in the morning up to 9 o'clock and in the afternoon as early as 4. The copulation lasts for about an hour.

22. A note on the development of *Ostrea cucullata*.

P. R. Awati *and* H. Rai, Bombay.

After a great deal of experimentation we succeeded in making an artificial fertilization in this species. The ripening of the eggs in this species seems to be influenced by the different phases of the moon. In the beginning of the new moon the eggs show amoeboid movements when unripe. The artificial fertilization was then invariably unsuccessful. Later on, i.e.

about the time of the full moon or even just before, these amoeboid movements ceased and the eggs were oval and the fertilization was successful. The sperms seemed not to have been influenced by the moon. They were active at all times.

The different stages of the development of this species were observed and figured. The morula stage was complete within 4 to 5 hours from the first division of the egg. Immediately afterwards within an hour or so of the completion of the morula stage larvae began to swim.

It was found difficult to rear these larvae for a long time beyond the Trochophore stage.

23. A preliminary report on the anatomy and life history of the common edible Back-Water Oyster, *Ostrea madrasensis.*

S. T. Moses, Calicut.

Distribution—Name—External appearance—Soft parts—Digestiv-system—Its food—Vascular system—The gills—Muscular system—Excretory system—Nervous system—Reproductive system—Spawning—Development.

24. A note on the development of *Oncis martensi.*

P. R. Awati *and* K. R. Karandikar, Bombay.

Eggs were laid in a large mass of gelatinous tubes on the back of another specimen in our laboratory aquarium early in the morning of the 5th August, 1926. Each egg was contained within a two-coated capsule inside the gelatinous tube. The zygote which was surrounded by the liquid yolk began segmenting after about two hours of the laying of those gelatinous tubes. The first division was equal but the later divisions were unequal and thus the micromeres and megameres were easily recognisable. The morula stage was reached within 48 hours and some movements within the capsule were distinctly visible. The Trochophore stage was complete after about 60 hours. The shell was being formed in the posterior part. The circle of cilia was limited to the anterior region forming afterwards the two velum lobes. The eyes, the foot and the operculun were noticed. The embryo was in the Veliger stage, moving freely within the capsule, at the beginning of the 5th day. On the 15th day the veliger came out of the capsule and led a free swimming life in water. On the 20th day the velum lobes together with big cilia were lost, the foot became bigger, the mantle was well developed and the larva no longer swam but crept along the surface of the substratum. The shell was cast off and the adult form was assumed. The dorsal eyes which are the characteristic organs of this family were not yet developed.

25. Observations on the breeding habits and fecundity of *Limnaea luteola* Lamarck, forma *typica.*

R. V. Seshaiya.

Observations on the breeding habits and fecundity were made for three years.

Limnaeae are found breeding right through the year. The individuals of *Limnaea* in a pond have each their own breeding period of life, but there is no breeding season for the species as a whole. The mode of laying eggs is described with sketches. Statistics and graphs for the frequency of laying eggs, as well as for the variations in the number of eggs laid in each batch, are given. Usually an individual lays eggs once in two days. The number of eggs laid by an individual in the successive batches alter-

nately rises and falls. Also, as the number of batches laid by an individual increases the number of the eggs tends to decrease. The minimum duration of life of *Limnaea* under natural conditions is probably three years. During its life-time, about 50 batches of eggs per year or 150 batches on the whole are laid. Each batch has an average of 33 eggs and about 5,000 eggs are laid on the whole.

The mating of *Limnaea* is described with sketches. After mating the individuals commence laying eggs in about a day. Sperms received in mating are not stored for any length of time before fertilisation. In the first year of its life, the animal is protandrous. At any rate the male genitalia ripen a little earlier. But in subsequent years, both sperms and ova are found to be ripe at the same time. There is a possibility but not probability of self-fertilisation. The genitalia of individuals of varying ages are sketched to show the growth of the reproductive system. Isolated individuals can breed for a long period. But parthenogenesis does not take place.

The fecundity seems to be influenced by environment. References to previous observations by some zoologists on the subject are made. The interesting problems presented by the breeding habits and fecundity of the species need further investigation.

26. Note on two species of hibernating Gastropod molluscs from the Kangra Valley.

H. S. Rao, Calcutta.

In certain groups of animals there is a seasonal variation in activity in response to changing conditions of environment. For instance, during periods of drought or extreme cold certain animals curtail their normal activity and fall into a state of torpor. This feature is common in many groups of terrestrial molluscs, but no detailed observations on this phenomenon seem to have been recorded.

In this note the author has given a short account of two instances of hibernation observed in members of two different families of molluscs, e.g. Succineidae and Zonitidae, under natural as well as artificial conditions. Both the species were found under stones in the month of May, 1926, on hill sides at Nurpore, Kangra District, Punjab, with the mouth of the shell closed by an operculum-like structure, usually called an epiphragm, secreted by the animals for their protection. The Succineid was sticking to a stone by its thin membranous epiphragm, while the Zonitid had a thick calcareous one and was lying loose in the ground without being attached to the stone. When placed in water both of them revived, threw off their epiphragm and began to move about. When they were removed from the water and allowed to dessicate in a dry place, they formed a fresh epiphragm in a short time. Further observations are being recorded.

27. On two species of fresh-water Polyzoa from Lahore.

Ch. Abdul Hamid, Lahore.

The paper deals with species of two genera of Polyzoa, collected in December, 1925, from small ponds of stagnant water near the Ravi bank. The species *Australella indica*, Ann., occurs in great abundance, growing over stems of water plants and twigs which lie immersed in water. The zoarium is entirely recumbent and spreads over a large area. It flourishes during September, and the zooecia begin to degenerate in the beginning of the cold weather, leaving thick masses of gummy secretion containing free statoblasts. Both free and fixed statoblasts occur abundantly. Each polypide bears 40 to 50 tentacles. The other species, *Plumatella fruticosa* Allman, prefers slightly dirty water and grows over stems of

water plants, twigs and deserted shells of fresh-water Molluscs. Fixed statoblasts are rare, while free statoblasts occur, but not so abundantly as in the above species.

Notes on the anatomy and histology of *Australella indica* are also given in the paper.

28. On the Fresh-water Entomostraca of Lahore.

Guran Lal Arora, Lahore.

The author has been engaged, for over a year, in studying the Fresh-water Entomostraca of Lahore, and, during the summer vacation (July to September), consulted all available literature on the subject in the Library of the Zoological Survey of India, Calcutta.

Of the 19 genera represented in the collection, two are new to science. The total number of species that have now been determined is 27, of which 13 belong to Cladocera, 10 to Ostracoda, 3 to Copepoda and 1 to Phyllopoda. In all, six species are new to science. The new genera and species are discussed in the present paper.

29. Influence of moist surface on oviposition response of *Aulacophora abdominalis* Fb. (Coleop.) and *Dysdercus cingulatus* Fb. (Rhynchota).

M. Afzal Hussain, Punjab.

During certain breeding experiments it was observed that these insects did not lay eggs on dry soil but readily oviposited on moist soil, wet blotting paper or even on glass on which water vapour had condensed. To find out if the real stimulus for oviposition was humidity of the atmosphere or actual contact with the moist surface, various experiments were performed and it was discovered that the atmospheric humidity was of no importance, the actual presence of moist surface being a factor essential for oviposition.

30. On the external morphology and anatomy of a new species of Embiadine with special reference to the spinning organs and its habitat.

S. Mukerjee, Calcutta.

The author worked for a period of two years at the Agricultural Research Institute, Pusa, on Embiopterans, an aberrant group of insects The collection in the Indian Museum is now being studied. Very little is known regarding these insects and all that is known is of a purely systematic nature and is very meagre. The author has worked in detail the anatomy of his new species, has made observations on its feeding habits and has tried to elucidate the facts regarding the exact position, structure and mechanism of the spinning organs.

31. On a new species of *Oligotoma* from Peradennyia (Ceylon).

Harendra Nath Ray, Calcutta.

In this paper the author describes a new species of *Oligotoma* from the collection of Embioptera in the Indian Museum.

Four male specimens were captured by Dr. Gravely at light in Peradennyia in August, 1910. It mostly resembles *O. greeniana* Enderlein, but in addition to some other minor peculiarities the left division of the 10th tergit of this species possesses a process which is absent in *O. greeniana.* The author has also observed the asymmetry of the mandibles.

32. The function of Anterior Tibial Spurs in *Amsacta albistriga*.

Y. Ramachandra Rao, Coimbatore.

Amsacta albistriga—the Red Hairy Caterpillar—is a serious pest of various crops in South India—especially groundnut and Cumbu (Bajri—*Pennisetem typhoideum*). The caterpillars when full-fed burrow to a depth of 4 to 9 inches in the soil and pupate there. They remain as pupae till the next monsoon, when after the fall of the first showers, the moths emerge from the soil, mate and lay eggs in thousands. Handpicking of the moths has been found to be an effective measure.

While studying the method of emergence of the moths from the soil, the writer was able to make certain observations as to the function of the peculiar tibial spurs noted on the anterior tibiae of moths. The anterior tibia is short and highly chitinised and is possessed distally of two spine-like elongations of which the interior one is as long as the tibia itself. These tibial spurs are used as shovels by the moth while finding its way up from the soil and the loosened soil particles are swept down by the other legs and consolidated at the bottom by the wriggling movements of the abdomen. As the digging, therefore, progresses, the tunnel thus burrowed out would be automatically filled up from below. Such structures are also noticeable in *Estigmene lactinea* which also pupates in the soil, while they are absent in *Pericallia ricini* which pupates on plants or on walls and ceilings of houses.

33. On the emergence of Mayfly swarms.

S. L. Hora, Calcutta.

It has been observed on several occasions that mayflies appear in swarms in continual succession for a few days (from three to eight days) and then they gradually disappear. During my recent tour to the Kangra valley (May-June, 1926) I was greatly impressed by this phenomenon, but I observed that swarms were only to be seen on moonlit nights. During dark nights I was unable to collect mayflies even with the help of an artificial light. All the streams visited were full of larvae, but flies were collected in those places where I happened to be during bright nights. The correlation between the dates of full-moon and the occurrence of mayfly swarms was so striking that in a letter from the field I wrote to Dr. Chopra about it.

With a view to throw further light on the subject the entire collection of mayflies in the Indian Museum was examined and where a dozen specimens or more were found in a tube, it was considered that they must have been collected from a swarm. Dates of swarms from published accounts were looked up and also those dates on which swarms were observed by the officers of the Zoological Survey of India were collected. Thus 27 instances of swarms were got together and it was found that 9 of these occurred between the first quarter and full-moon, 2 on the day of full-moon, 8 between full-moon and four days after that date and the remaining eight instances were on the days not included above. It may, however, be pointed out that most of the instances of swarms observed or recorded were found to have occurred about the dates of the full-moon, while the others about which there cannot be any certainty have shown great divergence from the observed facts. Enough material is not available at present to draw any definite conclusions, but this note is contributed with a view to draw attention to this problem.

I have one further observation to make on the emergence of mayflies. In the Broyi Khad on way to Upper Dharmsala I found three different types of flies coming out at three different times in one evening. A fairly big fly of the *Ecydurus* type with banded wings and very long caudal setae emerged two hours before sunset. They were found hovering over pools

at a height of 6 to 7 feet or more in small batches. Towards sunset they were replaced by black flies of the *Baetis* type, which never flew very high and were chiefly collected from sides of stones near small water-falls. Another fly of the same type but of a dull white colour was noticed flying close to the surface of water when it was quite dark. In the day time before noon *Caenis* were seen in large numbers in the same stream. Observations of this nature have already been made by Reaumur on *Polymitarcys* and *Palingenia.*

I have to express my great indebtedness to my colleague Dr. B. Chopra for the valuable help he has rendered in preparing this note and for the extremely useful suggestions he has contributed from his experience gained after a careful study of the mayflies.

34. The origin of yolk in certain Ova.

(*a*) In the eggs of spiders.

Vishwa Nath, Patiala.

In a paper of the oocyte of *Pholcus phalangiodes* (Arch. de Biol., tome 15, 1898), van Bambeke described a juxta-nuclear ring, the 'corps vitellin' which with the growth of the oocyte separates from the nucleus, and, after fragmenting finally throughout the cytoplasm, directly gives rise to fatty deutoplasm. He also described ordinary yolk spheres which are albuminous in nature and arise independently in the cytoplasm.

The writer is very much impressed by the remarkable accuracy of van Bambeke's account in spite of the very serious shortcoming of the technique in vogue in his time. The writer has shown that the 'corps vitellin' really consists of granular mitochondria, embedded in which are the golgi elements in the form of rings or crescents. The rings may also be appropriately described as vacuoles ('Vacuome' theory of Parat) with a sharp chromophilic rim and a central chromophobic substance (idiosome). van Bambeke figures granules and rings in his 'corps vitellin,' but naturally he was not able to identify them. The writer confirms van Bambeke's statement that the albuminous yolk arises *de novo* in the cytoplasm, there being no nucleolar extrusions. With regard to the origin of fatty yolk from the 'corps vitellin', it has been shown that the ring-like or vacuole-like Golgi elements swell up and are directly metamorphosed into fat spheres having free unsaturated fat. The theory of the origin of fatty yolk from the Golgi elements receives strong support from the stimulating researches of Parat who insists on the vacuolar nature of the Golgi elements which he has studied with vital dyes. There is no doubt that the Golgi rings look like vacuoles, and the fatty yolk spheres which originate from them are certainly vacuolar in nature.

(*b*) In the eggs of *Luciola gorhami.*

Vishwa Nath in collaboration with Dev Raj Mehta, Lahore.

There are two kinds of yolk in the eggs of *Luciola*, albuminous and fatty. The albuminous yolk spheres are perfectly round bodies which undoubtedly arise directly from numerous round nucleolar extrusions which microchemically behave exactly like the yolk spheres. At an early stage of the growth of the egg the nucleolus shows signs of the remarkable activity and continues to bud off round bodies of different sizes. This process lasts till a very late stage in oogenosis. At the beginning of this process the nucleolar extrusions migrate towards the periphery of the egg-cytoplasm where they grow in size, presumably at the expense of food materials derived from the follicle cells. Such origin of albuminous yolk from nucleoler extrusions has recently been described by Gatenby (*Sacco-*

cirrus), by Hogben (Cockroach and certain Hymenoptera) by King and Nath (*Lithobius*) and by Nath (*Buthus* and *Euscorpius*).

The fatty yolk spheres exist in the form of vacuoles containing free fat and undoubtedly arise directly from the Golgi elements which exist in the form of rings which may also be appropriately described as vacuoles having a sharp chromophilic rim and a central chromophobic substance (Idiosome). It is a very remarkable fact that the process of deposition of free fat in the Golgi elements begins in the undifferentiated germ cells. The theory of the Golgi origin of fatty yolk receives strong support from the recent researches of Parat and his co-workers. The origin of fatty yolk from the Golgi elements has also been described in *Saccocirrus* (Gatenby), in *Patella* (Gatenby and Woodger, Ludford, and Brambell), in *Helix* (Brambell), in *Lithobius* (Nath), in *Scolopendra* (Nath and Husain), in spiders (Nath) and most recently in *Oniscus* (King).

(*c*) In the eggs of *Scolopendra*.

Vishwa Nath in collaboration with Tasdique Husain, Lahore.

At the very beginning of the growth period of the egg of *Scolopendra*, the nucleolus buds off round bodies into the cytoplasm. This process lasts for some time till, at a particular stage, it ceases and the nucleolar extrusions in the cytoplasm completely disappear. After the disappearance of the extrusions, there is a long pause, after which albuminous yolk puts in its appearance and seems to arise *de novo* in the cytoplasm as is the case in spiders (van Bambeke, and Nath), although the possibility remains that the material of the nucleolar extrusions which have disappeared might contribute towards the formation of the albuminous yolk. At this stage the egg has assumed a large size and the nucleus lies just below the egg membrane. The behaviour of the Golgi apparatus is remarkable. In the youngest eggs it consists of a few juxta-nuclear rings and crescents. In Mann-Kopsch preparations the rings appear like vacuoles with a sharp chromophilic rim and a central chromophobic area (idiosome). The crescents also show a distinct idiosome material. The Golgi elements increase in number, so much so that the whole egg is full of them. The vacuole-like Golgi rings swell up and are directly transformed into the fatty yolk spheres which contain free unsaturated fat, as is shown by their blackening in Flemming-without-acetic and their quick decolorisation in turpentine both after Mann-Kopsch and F.W.A. When the fatty yolk spheres are blackened by OsO_4 they appear solid but when they are being decolorised in turpentine they appear like vacuoles with a black rim and clear contents exactly like the Golgi ring. Gradually the black rim also becomes colourless and the sphere remains as a clear white vacuole. An exactly similar process takes place in the eggs of spiders also (Nath). Furthermore, the fatty yolk spheres are never smaller than the Golgi rings, as should be the case if they were to arise *de novo*. Again, they appear only after the Golgi rings have increased both in number and size.

Lastly we emphasize the fact that, in all eggs in which the Golgi apparatus is said to give rise to yolk, such yolk is *always* fatty. This in itself is confirmatory of the above view, because the Golgi material is supposed to be a lipoid combined with a proteid.

35. Some observations on the life-history of *Luciola gorhami*, (Lahore fire-fly).

Dev Raj Mehta, Lahore.

The females were captivated in a cage for eight days. They laid their eggs on the eighth day in batches of four, and the total number of eggs

laid during one night was twenty-four. The eggs shine at night and continue to do so till they hatch ; their brilliance, however, decreases as they reach maturity.

The larvæ, just after emergence from the egg, are pale-white in colour, with strong mandibulate mouth parts. They have a root-like tuft of elongated processes, situated in the hindermost part of the body, which help in locomotion. There are two luminous spots at the penultimate segment of the body of the larvæ.

The pupæ are, at first, pale-white in colour. There are two luminous plates situated at the hinder segments, which emit a brilliant glow of light.

The adults, both males and females, can fly. The former have two luminous plates and the latter have one. They feed on grass and other succulent plants. During the day they hide themselves at the roots of long grass.

A detailed study is being made of the stages in the life-history of this beetle.

36. Preliminary observations on some South Indian Acarina.

M. C. Cherian, Coimbatore.

This paper deals with the observations as to the habits and life-histories of some Acarina met with in South India. 29 species representing 7 families are noted, the family Tetranychidæ having the largest number of species.

The classification followed is that of Nathan Banks and is given as Appendix A. A plate is also added giving figures of four species.

37. A study of Indian ticks of the family Ixodidae with special reference to mouth-parts.

M. Sharif, Calcutta.

The importance of ticks as disease carriers in man and domesticated animals has made them very popular with many parasitologists in other countries but in India so far they have been ignored.

The tick fauna of India is very rich in number of genera and species. The two families of ticks are represented here in India by eleven genera and about sixty species. Family Ixodidae alone claims nine genera and about fifty species of which as many as eight are new to science.

The mouth-parts in various genera of family Ixodidae show different kinds of modifications for taking firm hold of the host.

Different kinds of abnormalities are met with in Indian species of genus *Hyalomma* Koch and these are discussed by the author in detail.

38. An ant-like spider of the genus *Synemosyna* Hentz, 1845, from Barrackpore, Bengal.

Durgadas Mukerji, Calcutta.

The spider shows striking resemblance to ants in having its cephalothorax sharply separated into head and thoracic regions and in the possession of a short but distinct jointed pedicel between the cephalothorax and the abdomen. The abdomen is oval and due to a constriction on its dorsal surface looks like the abdomen of a Ponerine ant. The abdomen has a pair of longitudinal folds on its ventral surface. Anterior row of eyes recurved. Middle anterior eyes are the largest and nearly touch each other and are separated from the lateral ones. Chelicerae vertical and their bases are pluridentate. The pedipalps are short and the termi-

nal joint is flat. Cephalothorax brownish black, abdomen black. The abdomen is covered with a dense silky pubescence as in *Camponotus sericeus* Fabr., which it mimics. Legs 4,3,1,2 and black in colour but the undersurface of the two anterior pair of legs white. Length 5 mm.

A single specimen was collected from Barrackpore.

39. The circulation of mixed blood through the heart of *Ophiocephalus punctatus* Bloch.

S. H. Lele, Bombay.

In this air-breathing freshwater fish the blood which goes through the heart is not only deoxygenated blood as in an ordinary fish, but a mixture of oxygenated and deoxygenated bloods. This is due to the fact that the efferent branchials of the first two gills do not join the Circulus Cephalicus but ramify in the respiratory membrane of the suprabranchial cavity on each side. The veins of the suprabranchial cavities take this doubly oxygenated blood to the jugular veins. In the jugular veins it mixes with the deoxygenated blood from the head and is returned to the heart along with the deoxygenated blood from the other parts of the body. The larger portion of the mixed blood entering the heart at its diastole is driven to the third and fourth gills for oxygenation and later taken to the Circulus Cephalicus for distribution to the various parts of the body. The remaining portion of the blood in the heart goes to the first two gills and later to the respiratory cavities. From the latter it joins the stream of the venous blood to the heart, and goes to increase its oxygen-contents.

40. Early stages in the development of Gold Fish.

Hamid Khan, Punjab.

The spawning of the Fish observed in the Departmental Hatcheries at Madhopur in 1926 and 1927 Segmentation begins soon after fertilization, and 1 hour stage shows blastodisc divided into eight cells. Periblast is seen in 3 hours' stage. Embryonic axis appears in 10 hours' stage. Four somites are counted in 12 hours' stage. The differentiation of the Embryo progresses rapidly, and in 20 somites' stage after 16 hours embryo shows movement. In 20 to 27 hours' stage, heart and blood vessels make their appearance. Pigment cells have appeared and make the embryo opaque. Pectoral fins appear in 46 hours' stage.

The hatching depends on the temperature of water and takes 46 to 60 hours. The newly hatched out embryo has got the pectoral fins, and the segmental vessels. Just at the posterior end the posterior vena cava has got reverse circulation in a branch vessel. Three aortic arches are present but they increase in number the very next day. Opercular membrane appears over the gills on the second day, and caudal vessels give off a tiny branch to mark the beginning of the caudal capillaries. Yolk sac disappears altogether on the third day and a simple gut is formed; cerebral hemispheres and olfactory lobes, nostrils are seen in the dorsal view. Caudal circulation is advanced to the posterior extremity and three small basal cartilages make their appearance. Caudal rays begin to appear on the fifth day and on the ninth day the caudal fin is completely formed and separated off from the embryonic fin. Air sac appears 20 hours after hatching, an air bubble appears in it on the second day, and the chamber divides into two on the eighth day. On the eighth day the dorsal fin is segmented off from the caudal; and the ventral has got four rays developed in it. The embryonic development does not take more than three weeks; and, many fry of three months' age have been seen to change their original olive brown colour to bright red.

41. Remarkable vitality of Fish.

HAMID KHAN, Punjab.

One gold fish, nine months old, was attacked with fungus. It was given salt bath, and the affected portion was daily cleaned and rubbed with salt. At first the flesh began to peel off and then the whole of the vertebral column fell off and the wound got healed in a week, leaving only half of the fish quite healthy. Measurements of the fish were taken after six months : the length two inches only. Another example given in Fishing Gazette of 10th April, 1926, of a plaice 15 inches in length caught in a mutilated condition but its wound had healed and it was otherwise in a perfect condition. Ophiocephallidae with their accessory respiratory organs are the hardiest freshwater fishes. Examples are given of other fishes which possess remarkable vitality.

42. The manuscript drawings of Fish in the library of the Asiatic Society of Bengal.

S. L. HORA, Calcutta.

Owing to the rearrangement of the library of the Society, several interesting works have been rediscovered and among these the author has found four volumes containing drawings of fish. It is well known to the students of Indian Ichthyology that Hamilton Buchanan's original drawings or copies exist in the library of the Asiatic Society. Of much greater interest are the other two works, which besides the fish illustrations contain several zoological drawings. I have not found any notice of the latter works in the literature.

One of these is from the "Mackenzie Collection" and contains 26 drawings of common South Indian fish. These are not very accurate, but still I have been able to identify them fairly easily. They were drawn between the years 1794-1814 and thus we find that Col. Mackenzie was engaged in the study of fishes at about the same time as Russell and Buchanan. Among this collection are two views of a globe fish from St. Thomé River at Madras. The drawings show every characteristic of my new genus *Kanduka* from the Gangetic Delta and the Ennur backwaters and it is probable that they represent a new species or the adult of *Kanduka annandalei* from Ennur. There probably exists another volume of Mackenzie's drawings of natural history objects in the library of the India Office, London.

The last work to be referred to contains some drawings of fish from the Indus and the Kabul rivers and it appears that these drawings were made about the year 1836 by Dr. P. B. Lord, naturalist to Sir Alexander Burnes' mission to Kabul.

In passing it may be observed that the library of the Society is very rich in published and manuscript fish drawings and this is accounted for by the fact that the curators of its Museum in the early days were such eminent ichthyologists as McClelland and Blyth.

43. On some Frogs and Toads from the Punjab.

C. L. SAWHNEY, Lahore.

A collection has been made of frogs and toads from Lahore and several other districts in the Punjab. These include representatives of all the three families of Firmisterna and the family Bufonidae among the Arcifera. The genus *Rana* is represented by 7 species and *Bufo* by 2 species. Specimens referable to *B. melanostictus* exhibit a wide range of variation. Previous records concerning the occurrence of these and other forms are very incomplete.

An account is also given of some anatomical features of the common toad of Lahore.

44. On the occurrence of *Rana afghana* in the Western Himalayas.

S. L. Hora, Calcutta.

Rana afghana (Günther) has hitherto been known from the Eastern Himalayas, Khasi Hills, Assam, Southern Yunnan and hills of Burma as far south as Tenasserim. Its tadpoles possess well developed ventral suckers for sticking to rocks and stones in very rapid waters. During my recent tour to the Kangra valley (May-June, 1926) I found several tadpoles in a small rocky stream flowing into Charan Khad below Dharmsala. A single specimen was also collected in the Binnu Khad below the Dak Bungalow at Baijnath. Of this species there are no frogs in my collection and this is probably due to the fact that at this dry season they conceal themselves and thus escaped my notice in the field.

For verification the tadpoles were sent to Dr. Malcolm Smith, who has informed me that in the British Museum he has found larvae of *Rana alticola* Boulenger from the Western Himalayas. This is another species whose range was so far known to extend from the hills of Assam, Pegu, Siam to Tonkin and it has now been for the first time observed to occur in the Western Himalayas by Dr. Smith.

45. Little noticed habits of some birds of the District of 24-Parganas.

Satya Churn Law, Calcutta.

These relate to :—

(1) *Centropus sinensis.* The Common Coucal.
(2) *Merops viridis.* The Common Indian Bee-eater.
(3) *Terpsiphone paradisi.* The Indian Paradise Flycatcher.

(1) The first note embodies the results of my observations of the nesting habits of the Common Coucal. Its nesting period in the District begins as early as the middle of March; eggs are found in April, from which young hatch out towards the end of the month and by the middle of May the latter are full-fledged and able to come out of the nest. This record pushes forward the breeding period of *Centropus sinensis* three months ahead of what Blanford observed in F. B. Birds Vol. III. The full clutch of the eggs taken by me has been four, and not three as noted by Blanford. The nest is built usually in bushes or thickets, not uncommonly in trees, and even in grass jungle. The nesting materials vary according to the exigency of the situation where the nest is constructed. In nine cases out of ten of the nests I came across, they were without any dome and never "open at the top" as recorded by Col. Butler, but well-ventilated and thoroughly clean, the entrance being large and elliptical. A sketch of a nest in *situ* which was found on 24th March, 1926, is annexed by way of showing the arrangement of the nest materials and their attachments to the stem and branches. My observation is also noted regarding the posture of the sitting bird within the nest.

(2) The second paper records the results of my attempts to study the movements of the Common Indian Bee-eater during its nesting period. These birds, which are commonly found to go about in parties, disband and scatter themselves into very small units at the advent of their breeding season. These units retire to unfrequented parts of the village, where their breeding areas lie. They now consist of two or three pairs of birds and sometimes of a couple only, each couple digging for its nest at some distance apart from the other. Notwithstanding the publicity which the

bright colour of their body together with their sprightly habits and numerical strength in a locality vouchsafes for them, the process by which the spiriting away of a whole flock from their familiar haunts is effected is so mysteriously surreptitious as to produce the impression that they are migratory birds which may now have left the District for their summer quarters. It is noteworthy that though disbandment at the nesting season is of distinct advantage to the perpetuation of the race, this custom does not appear to be uniformly followed; for instances are not rare even in the District of 24-Perganas, where after the process of disbanding has been completed, the units re-unite in their breeding area and thereby revive the old congregation. The high bank of a canal or stream or the steep face of an embankment will in such cases afford a congenial site for reunion.

The relation between the shape (e.g. depth, declivity and direction) of a Bee-eater's nest and the nature of the earth (either hard or soft) where its burrow is made affords a highly interesting study, and what little observation I could make on the point has been recorded in this paper with the aid of diagrams of some nests I discovered during March and April last in a village about twelve miles to the north-east of Calcutta. The illustrations also show the normal shape of the egg-cavity or nesting-chamber. In diagram C, however, the abnormal shape of an egg-cavity has been shown. The behaviour of the sitting bird has been noted in the face of danger like the act of cutting open these nests, when its body becomes exposed and earth and dust crumbles down upon it. The normal clutch of eggs hitherto observed by me has been almost invariably six, but Blanford and Hume mention five as the maximum number. If, however, I came upon five young in one single nest, there was always an unhatched egg (evidently infertile) lying in a corner.

(3) An attempt has been made in this third note to remove the erroneous impressions hitherto extant, regarding the movements of the Indian Paradise Flycatcher within the District of 24-Perganas. It is not a migratory bird—"arriving in April and remaining until the middle or end of October" as Munn seems to suggest. Nor is it a "seasonal visitor" here but a permanent resident which although it shows its preference for a particular locality during the nesting season, is generally not attached to any circumscribed haunt. In this district it moves about locally in parts of its habitat, though a few instances came to my notice of a single pair of *Terpsiphon p. paradisi* sticking to a favoured spot throughout the year in the heart of a village about 13 miles distant from Calcutta. Mr. Stuart Baker is inclined to ascribe its roaming habit to the exigency of its food conditions.

All the available records of the nidification of this bird point to May and June as being its normal breeding period. But my observation is that in April it sets about building its nest so that by the last week of this month the nest is not only complete but its full clutch of eggs is laid. Throughout May, June, July and even in the second week of August, I have observed its nests, eggs or young. The cock bird has in several instances been watched by me in the act of sitting on the eggs within the nest. This observation disproves what Munn wrote (Ibis. 1894) about the female "apparently doing all the work, for the cock bird at this time is extremely shy and generally remains quietly perched in a tree near the nest."

46. Notes on the Fauna of the Bombay shore.

I. Hydrozoa.

P. R. Awati, Bombay.

The following are the forms which have been collected from the pools found between the tide marks or in the edge of the low tide.

In the absence of literature in Bombay it has been found very difficult to identify the species of these forms and hence I am constrained to give their generic names only.

1. *Pennaria* (*Halocordyle*).
2. *Tubiclava.* On a gastropod shell.
3. *Corymorpha.*
4. *Companularia.*
5. *Sertularia.*

The full description of these forms will be given in my paper.

II. Gephyrea (Armata and Achaeta).

The following are the forms which have been found in the sandy mud between the tide marks. The generic names only of these forms are given below owing to the absence of any literature at hand.

1. *Thalassema.*
2. *Phymosoma* (A).
3. *Phymosoma* (B).
4. *Dendrosoma signifer.*

The morphology, the anatomy and the development of these forms are being worked out at present and will form the subject matter of my paper.

III. Onchidiidae of Bombay.

P. R. Awati, in collaboration with K. R. Karandikar, Bombay.

The Onchidiidæ of the Bombay shore consists mainly of three different species, two of which belong to the genus Onchidium and the third to Oncis. These forms are found on or below rocks on mudflats between the tide marks.

1. *Onchidium verruculatum.*
2. *O. simrothi.*
3. *Oncis martensi.*

The full description and the bionomics of these forms will be given in our paper.

IV. Ostreidae of Bombay.

P. R. Awati in collaboration with H. Rai.

The following Edible Oysters are collected from the Bombay shore, which have not been recorded before on this shore. The distribution of these forms present an interesting problem.

1. *Ostrea cucullata.*
2. *O. gryphoides.*
3. *O. virginiana.*
4. *O. edulis* (variety ?).

The full description and the distribution etc. of these forms will be given in our paper.

47. Preliminary observations on the fauna of the Kangra Valley.

S. L. Hora, Calcutta.

The author paid a visit to the Kangra valley in May-June, 1925 with a view to study its fauna. It was very hot in the valley and this period was considered to be the driest part of the year. As was to be expected

very few terrestial forms were obtained and those that were procured were found in shady places or in damp localities in a more or less torpid condition. The time of the year chosen, however, proved to be very successful for the collection of the aquatic fauna as most of the streams contained a fairly large quantity of water. Most of these are perennial streams being fed by snows from the Chamba hills throughout the year. Water in the streams is very cold at all seasons of the year. The outstanding feature of the collection is the presence in large numbers of nymphs or larvae of such insects as Dragonflies, Mayflies, Simulids, etc. The collection has not yet been worked out, but in this session of the Congress some aspects of the fauna are discussed in a number of notes. It is, specially significant that the collection is not only extremely rich in individuals but it also contains a large number of species.

The special interest of the investigation of this area lies in the fact that it is situated on the border land of the two main zoo-geographical regions *viz.*, the Oriental and the Palæarctic.

Section of Botany.

President:—Prof. M. A. Sampathkumaran, M.A., Ph.D.

Presidential Address.

(The text of the address was not received in time for inclusion in the Proceedings.)

Abstracts of Papers.

1. Algal flora of the Chilka-Lake, Ganjam District, Madras Presidency.

Kalipada Biswas, Calcutta.

This monograph contains a detailed account of the algal flora of the Lake as well as a short sketch of the geography, hydrography and other physical features and the phanerogamic vegetation of the Chilka Lake and of the islands within it. The biological comparison of the Chilka Lake with those of the Calcutta Salt-Lakes and a thorough investigation into the plankton flora form important features of the monograph. Some of the plants described in this paper have been reported for the first time from India. The materials have been collected by the late Dr. N Annandale and the author during the years 1914 to 1925.

2. On a new genus of the Scytonemataceae.

Yajnavalkya Bharadwaja, Benares.

The writer has found a new filamentous blue-green Alga growing as epiphyte on an aquatic angiosperm in a pond near Benares Hindu University grounds. The Alga differs a good deal in details as regards the cells of the trichomes, pseudobranching, heterocysts and the formation and contents of the spores from the present known genera. It can not be referred to Plectonema on account of the presence of heterocysts, nor to Scytonema because the branches are always single, nor to Tolypothrix, as there is no heterocyst at the point of ramification. It does not resemble Campylonema even because the filaments do not possess crescentic shape and the geminate pseudobranches, which have been described in *Campylonema Lahorense*,, are totally absent. There are various other points which make it quite different from any of the genera already known. Many cytological details have also been observed confirming some of the observations of West, Fritsch and Crow.

3. The sub-aerial blue-green algae of Rangoon.

S. L. Ghose, Rangoon.

An account of the sub-aerial blue-green algae of Rangoon, chiefly from an ecological point of view is given.

These algae have various habitats, such as damp soil, moist roofs and walls of buildings, damp wooden palings, sides of drains, barks of trees.

Twenty species of blue-green algae are dealt with, and their usual habitats in Rangoon and other places are described and discussed.

Three interesting facts in connection with the ecology of these algae are noted: (1) the predominance of sub-aerial forms over purely aquatic species, (2) absence of spores in a majority of sub-aerial forms, (3) the fact that many forms which usually live in water in Europe are found in sub-aerial habitats in Rangoon.

4. Characeae of Bombay and Salsette Islands.

S. C. Dixit, Bombay.

Following species of Nitella and Chara are for the first time reported from the place:—

1 *Nitella oligospira*, 2 *N. acuminata*, 3 *N. hyalina*, 4 *Chara brachypus*, 5 *C. zeylanica*, 6 *C. flaccida*, 7 *C. macilanta*, 8 *C. macropogon.*

The last named species of Chara is for the first time reported from India. It adds to the list of species found in India. Ecological observations are noted, *Nitella hyalina* and *Chara macropogon* are distinctly living in the Sea-water. There are still two species awaiting identification. Preserving medium comprising of the following chemicals is suggested:—

Copper Nitrate ·2 gms. Copper chloride-*w*-·2gms.
Acetic acid ·5c.c. and 2% Formalin solution to make up 100cc.

5. Three species of Debarya from South India.

M. O. Parthasarathy Iyengar, Madras.

Three species of *Debarya* from South India are described in the paper. Two of these were collected by the author from some rock-pools in the bed of the river, Sharavati, just above Jog falls in the Mysore Province: the third was collected in a tub in Madras. While the Madras species comes very near *Dobarya desmidioides* W. & G. S. West, the two Jog species appear to be new.

One of the two species collected at Jog is extremely interesting in forming plenty of azygospores in addition to the usual zygospores by normal conjugation between the cells of adjacent filaments, the same filament very frequently showing both conjugation and azygospore formation. Azygospores are the only method of reproduction known in *Gonatonema.* They have also been recorded in some species of *Mougeotia.* But so far, no azygospore formation has been known in *Debarya.* During the formation of the azygospore the same kind of filling of the cell with the refractive cellulose material takes place as is seen during the formation of the zygospore by conjugation, while the fully developed zygospore possesses four solid cellulose processes attached to it, the fully developed azygospore possesses only two.

So far, only one species of *Debarya* (*D. desmidioides* W. and G. S. West var. *orientale* N. Carter), has been described from India, and that only a few months back from a collection made in North India.

6. Studies on the root nodule organism of the leguminous plants.

Piyare Lal Anand, Lahore.

Cross inoculation experiments carried out in this Laboratory tend to indicate that there is only one species of the legume nodule organism, if we take nitrogen fixation and stimulation thereby as the essential function of the organism. If however nodule formation is taken as the sole physiological test for distinguishing the species, then naturally the above conclusion will have to be modified.

Nodule formation has been found to occur when *Pisum sativum* is inoculated with *Faba vulgaris radicicola* thus resulting in the elimination

of numbers 4 and 5 groups of German and Didlake, that should be grouped as one.

Even when the bacteria do not form any nodules it was clearly seen, that the plants derive benefit by inoculation. The growth in those cases was much more vigorous and a greater development of the roots than the uninoculated control plants.

The nodule organism gave the best kind of growth on soil extract mannite agar, solmedia and decoction of legumes plus 5 % asparagin, plus 2% sugar.

Infection of the roots is through the root hairs, later on producing a gelatinous strand cutting off buds in the uninfected cells. There is a hollow space in the centre of the older nodules due to the disorganisation of the bacteroids and their assimilation by the plant. The vascular bundles of the nodules have a reverse arrangement of the conduction tissue than the normal roots.

7. Studies in the biological and cultural characters of Capnodium on cotton.

A. Sawhney.

The seeds of Sea Islands and American cottons received from Dharwar were sown along with those of the Desi cotton in three small plots in the Botanical Gardens, Lahore, on the 6th of May, 1925.

In October of the same year the writer on visiting these plots found that some of the cotton plants had dark specks of fungal growth on 1–3 chief veins of the leaves on the under surface. The specimens were sent to the Mycological Department, Pusa, where they were identified as a "Capnodioum sp. which has not as yet been described on cotton."

Capnodium occurs along with Alternaria and Macrosporium on the leaves and balls of the glandular cottons and is the cause of the black specks found on the glands at these places. The infection is most prominent in the Sea Island, less so in the American cotton, and least in the Desi glandular. The infection in nature is entirely limited to the nectary glands as no infection was noted in non-glandular Desi cotton though it was severely attacked by Aphids. The disease appears to be originally confined to the Desi glandular cotton and is prevalent throughout the whole Punjab plains. From this it passes to the foreign cottons when they are grown here, and finding hosts suited more to its needs it flourishes the more on them.

When artificially innoculated the fungus is capable of infecting the other parts of the plant as well as the non-glandular variety.

The action of the fungus is not "purely saprophytic as in other species of Capnodium, but parasitic for it does not subsist on the "honey dew" of insects but lives on the secretions of the host. A full account is given of the life history of the parasite and of its effect on the plant.

There are two maxima for the pycnidia in each medium, where they are most abundant and largest in size, one in low and the other in high concentrations.

8. The 'Blast' disease of rice and its control.

S. Sundararaman *and* K. M. Thomas, Madras.

The 'Blast' disease of rice (*Piricularia oryzae*) being not amenable to direct treatment, an attempt was made at Coimbatore to study the degree of resistance in several varieties of Rice.

The plan of experiments and the method of recording results are mentioned.

The varieties exhibited different degrees of resistance.

In one and the same variety, difference in environment produced remarkable difference in the incidence of the disease. Greater vegetative growth indicates greater susceptibility to disease.

The chief avenue of fighting the disease appears to be the selection of resistant varieties.

Recommendations are made to eliminate very susceptible varieties, and to test new strains for Piricularia resistance before they are distributed to the cultivators.

9. Observations on *Thielaviopsis paradoxa.*

T. S. Ramakrishnan, Madras.

The fungus was isolated from sugar-cane sets obtained from Cuba and its growth on agar media and the germination of the spores were studied. A comparative study of the measurements of the macroconidia obtained from four hosts inoculated with the same culture of the fungus showed that there was no appreciable variation in size.

Inoculations were made with the fungus on the different hosts known to be parasitized by *Thielaviopsis paradoxa*—coconut, pine-apple and sugar-cane. There was some variation in the severity of infection in the three different varieties of sugar-cane that were experimented with. Coconut stem and petioles were infected through wounds. Wounded pine-apple leaves were readily affected by the fungus.

In addition to these, inoculations were made with the fungus through wounds on four palms—Arecanut, *Rhapis flabelliformis*, date-palm and palmyra. The stem in the first two was readily infected. In the third the petioles alone were tried and found to take infection. The last, however, did not show any appreciable amount of infection.

Besides sugar-cane, *Saccharum spontaneum* was found to be affected. Beet root tubers and sweet potato tubers were not affected.

Ripe fruits of mango and plantain took the infection through wounds. Young and unripe fruits and the shoots of these were not affected by the fungus.

It is interesting to note that the hosts of the fungus belong to the monocotyledonous group. The strain of the fungus isolated from one host is able to infect the other known hosts also. It effects an entrance mostly through wounds.

10. Some observations on varietal resistance to 'Rust' of Coffee.

K. M. Thomas, Madras.

Different varieties of Coffee growing under identical conditions of soil and climate, exhibit varying degrees of resistance to 'Rust' (*Hemileia vastatrix*).

A study was made of the leaf anatomy of five varieties of Coffee growing in Coorg with a view to discover factors governing Rust-resistance.

The structure of the parenchyma and the structure, size and distribution of the stomata do not bear any relation to resistance.

The presence of a large number of globules of an oily or waxy origin was detected on the lower epidermis of the leaves as well as in the parenchyma cells.

The number, distribution and period of fusion of the wax globules on the lower epidermis bear a direct correlation to Rust resistance. In the resistant varieties, the globules are larger in number and they tend to fuse at a later period than in the susceptible varieties.

The examination of the lower epidermis of 4-5 pairs of leaves in a serial order constitutes a simple means of gauging Rust resistance; and this method could be used with advantage in the laboratory, in adjudging relative resistance, from limited samples.

11. Gummosis of Citrus trees in the Bombay Presidency.

M. N. Kamat, Bombay.

A short history of previous investigation into the disease is given. Some of the important contributions being those of Briosi in Italy, Mc.Alpine in Australia, Saurer in Germany, and Smith, Butler, and Fawcett in America.

Damage done by the malady is calculated at not less than 10–15 per cent every year and the younger plants succumb to the ravaging disease more readily than older plants.

Field characters are described in detail; exudation of amber coloured gum at bud joint and longitudinal peeling of bark and discolouration of wood at this place being some of the conspicuous symptoms. Two types of gummosis—collar gummosis and branch gummosis—are described. Premature flowering and bearing in the case of gum affected trees has been conspicuously noticed and considered to be due to certain stimuli not yet clearly understood.

Inoculations with Phycomycete fungus (*Pythiacystis citrophthora*) obtained from the bark of affected plants have given positive results in all cases.

Inoculations carried out upon the jamburi stalk have reproduced the disease only in a very mild form, suggesting that very probably the stalk is resistant to the attack of gummosis.

12. Gall formation on the roots of mustard due to a smut (*Urocystis corraloides* Rostrup).

M. Mitra, Dacca.

Urocystis corraloides is a very rare smut, and having been only twice reported on the roots of two cruciferous plants in Europe, viz. on the roots of *Turritis glabra* by Rostrup in 1881 and by Lagerheim on the roots of *Matthiola sinuata* in 1899.

It has been found in India on the roots of *Brassica compestris* var. sarsoon (mustard) only in one small plot of mustard where it occurs year after year and has not been found in any other mustard crop though a good deal of search has been made.

This smut is interesting on account of tuber like large gall formation upto 1″-1½″ in diameter on the underground parts and also because it is very rare. Very few smuts are known to attack underground parts of a plant. The fungus infects mustard plants when seeds are sown in pots containing infected soil, but so far spores have not been found to germinate under laboratory conditions.

13. Fruit-rot disease of cultivated Cucurbitaceae caused by *Pythium aphanidermatum* (Eds.) Fits.

M. Mitra, Dacca.

Pythium aphanidermatum (Eds.) Fits. has been found doing considerable damage to various cucurbits which are used in India as vegetable and causes fruit-rot.

It has been isolated from *Luffa acutangula*, *L. aegyptiaca*, *Trichosanthus anguina*, *T. dioca*, *Cucumis sativus*, *Lagenaria vulgaris*, *Momordica charantia* and *Cucumis melo* var. *momordica*.

The results of inoculation and cross inoculation experiments prove that all strains isolated are identical and that they are parasitic.

The fungus is more prominent on fruits than on leaves and stems and forms a luxuriant woolly mycelium weft. The tissue in the interior of the fruits becomes watery and soft and the decaying matter emits a bad odour.

The sporangia formation is like those of Pythium belonging to the gracile group. The fungus grows very well in cultures of different kinds, especially on meal agars and forms plenty of oogonia and oospores. The sporangia and zoospores are not formed in any solid media but are formed copiously in water culture or on boiled ants in water within six hours.

Pythium aphanidermatum (Eds.) Fits. is closely allied to *Pythium Butleri* but is not identical.

14. A note on the morphological characters of two physiological species of *Puccinia graminis* Pers.

K. C. Mehta.

Discussion on observations made by Eriksson and Stakman on sori and uredospores as found in nature.

Observations by the writer on sori and spores cultivated on normal hosts and hosts that are ordinarily resistant.

P. graminis secalis cultivated on rye, wheat and barley.

P. graminis tritici cultivated on wheat and barley.

Comparisons with material found in nature.

15. A preliminary note on the infection histology of two physiological species of *Puccinia graminis* Pers.

K. C. Mehta.

Discussions on Pole Evans' work on distinct "morphological species" of the genus Puccinia.

Observations made by Eriksson and Ward on "physiological species."

The writer's work on infection histology of *P. graminis tritici* and *P. graminis secails* cultivated on wheat and barley in one case and on wheat, rye, and barley in the other.

16. A note on the infection histology of *Puccinia triticina* (Dispersa) Eriks and Honn.

K. C. Mehta.

Discussion on Murryat's work on *P. glumarum tritici.*

Observations made by Ward.

The writer's work on infection histology of *P. triticina* cultivated on Burbanks and Einkorn wheat.

Sori and spores on susceptible host.

Sori and spores on immune host.

17. Notes on *Riccia robusta* Kashyap.

S. K. Pande, Lucknow.

In January last, I found in a hand section of *Riccia robusta* indications of there being two archegonia in a single pit. This is an unusual thing for the Ricciaceae where, so far as I am aware sex organs are found singly in pits.

As our knowledge of this species is confined to the brief notes published by Professor Kashyap in the Journal of the Bombay Natural History Society Vol. XXLV, No. 2, a somewhat detailed study was carried out.

In the material of the species examined by Prof. Kashyap, he has seen no scales and has also been doubtful about the presence of antheridia.

The material under investigation shows undoubted antheridia and scales. The development of both of these is of the usual type.

The development of the archegonium and the sporophyte agrees with the account given for other species of *Riccia* and as a rule one archegonium is found in each pit but sometimes there may be two of these together lying side by side.

18. Notes on morphology and the development of the sporophyte of *Notothylas indica* Kashyap.

S. K. Pande, Lucknow.

Notothylas indica grows rather abundantly during the rainy season in some of the shady places at Lucknow.

According to Prof. Kashyap this species is dioecious but an examination of the Lucknow plant shows that the species is monoecious and probably protandrous.

The paper gives a detailed account of the mode of formation of the archesporium and the origin of the columella.

In July last some young plants of *N. Levierie* were brought down from Mussoorie to be grown under experimental conditions but they died soon. I propose to carry this study later on.

19. The comparative anatomy of *Ophioglossum Aitchisoni* D'Almeida; and *Ophioglossum Vulgatum* L.

Bhagat Ram Vasisht.

O. Aitchisoni was found in July, 1925, growing in a grassy place in a village in the Hoshiarpur district, and *O. vulgatum* was found growing near the small drying pools along the bank of the Ravi in Lahore.

A study of the comparative anatomy of both these plants was carried on in the Botanical Laboratory, Lahore, and the results are described in detail.

20. Male flowers and microsporogenesis in *Pinus longifolia*.

M. L. Sethi, Lahore.

There is no winter rest preceding miotic divisions in *Pinus longifolia*, which take place in the last week of January. Microsporogenesis has been studied by the smear method. Chromosome tetrads during prophase of the heterotypic division and quadripartition by furrowing in the mother cells are being described for the first time in *P. longifolia*. The diploid and the haploid number of Chromosomes are 24 and 12 respectively.

21. On the occurrence of the funnel-like leaves (Ascidia) in *Ginkgo biloba*.

B. Sahni, Lucknow.

Describes the occurrence of ascidia in specimens of this species in Lahore and Mussoorie.

22. On some petrified cones of Indian fossil conifers from the British Museum, London.

B. Sahni, Lucknow.

The author will describe and exhibit several species of female cones showing internal structure. Petrified cones of conifers have not so far been described from the Indian strata.

23. Replacement of fertile shoots by vegetative shoots in *Euphorbia tibetica* Boiss.

Shiv Ram Kashyap, Lahore.

Many plants of *Euphorbia tibetica* have been observed by the writer in Western Tibet in which the fertile shoots were replaced by vegetative shoots—the phenomenon being quite common there in these plants. Some other variations are also described.

24. Apocarpy in a cultivated variety of *Solanum melongena*.

C. M. John, Madras.

Though variations in the number of corolla lobes, number of stamens, colour, shape, and size of fruits of Brinjal (*Solanum melongena*) are very common, the presence of more than one pistil in a flower, has not hitherto been recorded.

The paper describes an apocarpous condition of the pistil due to a longitudinal split. Drawings and photographs illustrating these points are appended.

25. The medullary bundles in *Achyranthes aspera* Linn.

P. M. Somasundaram, Madras.

An account of the arrangement of the bundles in the plant illustrated by microscopic sections and diagrams.

26. On the morphology of the flower and the embryology of *Vallisneria spiralis* L.

K. Rangasamy, Bangalore.

The ovary is three carpelled and unilocular. The nucellar projections, though parietal, appear all round the wall of the ovary and there is no definite region where the placentum is distinctly developed.

The development of the integuments, which are two in number, starts a little later. The inner integument completely encloses the nucellus, while the outer is still seen developing half-way.

The megaspore mother cell appears as the central cell in the third layer of the nucellus from the micropyle, and its nucleus divides by reduction division.

After the first division, the upper cell does not undergo any further division, The lower one divides once more. Of these the lowest cell forms the embryo-sac.

The egg apparatus is of the usual angiospermic type.

Several stages in the embryo, of the same plant have been observed from the earliest to the latest and they all conform to the embryology of Elodea described by Wylie. The principle of development is of the Alisma type described by Schaffner.

The ovules are all orthotropous with a fairly large funiculus. Seeds are exalbuminous.

27. Origin and nature of the shoot-axis (Stem) and the primary root.

G. P. Majumdar, Calcutta.

In this paper—

Miss Saunder's ' Leaf-skin theory ' is criticised.

Bower's ' Strobilus theory ' is critically examined.

An attempt is made, by a careful study of the development of the embryo, the growing points and other structures of the *Hepatics* the

Mosses, the *Pteridophytes* and the *Phanerogams*, to establish that the *Shoot-axis* has been gradually evolved out of the union of the bases of the "Chlorophyllous assimilating foliage leaves" and that the *Cormophytes* are really the *Phyllophytes* of Delpino.

Origin of primary root is also discussed, and an attempt is made to show that the radicle is produced by the downward prolongation of the united bases of the first pair of leaves or of the base of a single leaf, as the case may be, in the embryo.

Schematic diagrams of the nature of the shoot-axis and the origin of the primary root are given.

A suggestion is also made as to the probable evolution of the Fern sporophyte from the Moss sporogonium. The Moss sporophyte—a leaf equivalent—is distinguished into three parts—the *stalk*, the *apophysis* (green vegetative middle portion) and the *upper part* transformed into sporogenous region. In fern the sporophytic stage is not confined to the production of a single leaf or leaf equivalent but many leaves are to be produced and for their production an embryonic cell is early cut off in the embryo. The sporogenous transformation of the leaf, or the production of the sporophylls is deferred for some time with significance.

28. Anatomical and physiological investigations on two species of Mimosa.

PYARE LAL ANAND, Lahore.

The paper deals with a thorough anatomical study of the stem, leaf and stem apex of two species of Mimosa:—*Mimosa pudica* and *Mimosa sensitiva*. The leaves in *M. pudica* had four leaflets while there were only two in *M. sensitiva* and consequently there was not much difference in the anatomy of the petiole except that there were four bundles in the former and two in the latter.

Each stem as well as the petiole bundle consists of sclerenchyma on the outside, then phloem consisting of sieve tubes intermixed with patches of phloem parenchyma, then Cambium separating the phloem from the stem and lastly thin walled parenchymatous cells.

The traces of the leaflets are formed of vessels from the upper, lower as well as the lateral bundles of the petiole. At the stem apex the vascular bundles emerge into the undifferentiated meristematic cells.

By the help of bundle stains a clear line of demarcation was shown between the active and non contractile cells of the leaves.

There was neither any transmission through water gap nor any excitement observed when the cut ends of the stem were put in an extract of stem slices.

29. The exudation of mucilage by adventitious aerial roots of *Sorghum vulgare*.

K. VENKATARAMAN, Aduturai.

Adventitious aerial roots are found to occur on the lower nodes of the stem of *Sorghum vulgare*, and the tips of such roots have been observed to secrete mucilage. The anatomical and physiological aspects of the mucilage-exudation formed the subject of investigation, and the results obtained warrant the following conclusions.

Mucilage is formed by the disintegration of the cells near the region of the root-tip, and three distinct stages are noticeable in this process.

The layers of the mucilage-sheath at the tip of the aerial root, correspond morphologically to the layers of the root-cap cells of the normal underground root. Contact-stimulus with moist soil appears to determine the development of the root-cap; in underground roots, and the absence of that stimulus in aerial roots leads to the disintegration of cells and the formation of mucilage. This statement is supported by the observation

that a young aerial root surrounded by moist-soil, developed the root-cap instead of the mucilage-sheath.

The results of a few simple physiological experiments indicated that the mucilage (occurring at the tips of aerial roots) is of purely external origin, and serves two functions. It affords a protective coating to the tender tip region, and mechanically prevents loss of water by evaporation. Secondly, it absorbs moisture from the atmosphere, securing a supply of water to the root; and in this respect it presents a strong resemblance to the 'velamen-tissue' found in the aerial roots of orchids.

30. On the physiology of potato tubers.

Jai Chand Luthra *and* Bansi Lal Batra, Lyallpur.

Storage of potato tubers for seed purposes is an important matter in the plains of the Punjab. Considerable loss due to mere rotting attributable to high temperature in the summer months occurs every year. The object of the work reported in the paper was to study the metabolic activities of the tubers during storage. Potatoes graded into large, medium and small sizes were taken in two lots for the experiments, One set was stored at the room temperature varying between 95°-115°F and the second lot was kept at 70°-75°F. Figures of loss in weight due to transposition and decay in the two lots are recorded.

Respiration rate was determined in sound tubers at the initial stages and then after storing them. Tubers in which rot had set in respired fast. Variation in the rate of respiration during the course of the experiment were studied.

Depression of the freezing point was determined and the amount of sugars present in the tubers was calculated.

31. Respiration of ripening Ricinus fruits.

P. Parija, Cuttack.

The respiratory quotient of fruits and seeds of different ages is found to vary with age.

In the very young stage the quotient is less than unity and as the age advances it becomes as high as 2, 3.

In order to explain the discrepancy it is suggested that the actively growing fruit consumes some oxygen which is not represented in the CO_2 produced, and the bigger ratio observed in the later stages is explained by the assumption that the fruits derive oxygen from the conversion of carbohydrates into fats.

32. Relations between water content and the rate of photosynthesis with an increased supply of carbon dioxide.

R. H. Dastur *and* R. E. Cooper, Bombay.

In a previous paper last year by one of the writers it was shown that the rate of carbon assimilation of a leaf depended upon its water content, the leaf having high water content assimilating more carbon dioxide than the leaf having low water content. The rate of assimilation was then measured under constant and uniform conditions with a specially contrived apparatus, where the leaf was allowed to remain attached to the plant.

In those preliminary experiments the source of carbon dioxide was ordinary air. In the present investigation the rate of assimilation of a leaf was determined with increasing percentage, by volume, of carbon dioxide with a view (1) to determine the rate of assimilation with this special apparatus as the investigations by different workers on photosynthesis have been made in the past on the plucked leaves, and (2) to find

out the relation between the rate of assimilation and the water content of a leaf when the supply of carbon dioxide is steadily increased.

The same apparatus was used with certain changes to regulate the temperature which is kept constant at 30°C which is generally the room temperature in Bombay. A constant source of artificial light is used. The results obtained with the leaves ot *Abutilon asiaticum* G. Don. show that the rate of assimilation increases with the increase in the carbon dioxide content and the rate of assimilation is limited by the water content of the leaf.

33. On the nyctitropic movements exhibited by the cotyledons of *Cassia tora.*

N. K. Tiwary, Benares.

No case in the knowledge of the writer, of the nyctitropic movements of cotyledons, seems so far to have been recorded. The cotyledons of *Cassia tora,* however, have been noticed to execute sleep-movements exactly similar to those of the foliage leaves of the plant. This paper gives an account of the observations made by the writer on the behaviour and the anatomy of the cotyledons. A comparative account of the behaviour and anatomy of the foliage leaves is also given.

34. On the behaviour of the radicle and plumule of species of Eugenia during germination, and its probable significance.

N. K. Tiwary, Benares.

During the course of his investigations on the phenomenon of polyembryony in Eugenia, the writer has repeatedly noticed examples of the doubling of the plumule and the radicle during the germination of the seeds. This doubling takes place either at the very beginning of their growth, so that the branches are quite distinct except for a very abbreviated common portion of the axis, or they branch off from the end of a more or less well developed common axis, which often shows its double nature by the presence of a groove. An account of this is given as noticed in several species of Eugenia. On comparative grounds the writer believes these to be merely different aspects of polyembryony.

35. Experimental researches on the growth of tropical plants. Part I :—A comparative study of the growth-rates and respiration throughout the life-cycle of the Radish plant during successive periods of growth in relation to the leaf-area and the leafweight ratios.

Bhola Nath Singh *and* V. V. Apte, Benares.

The present series of investigations was undertaken in continuation of the previous work on "The growth of the Cotton Plant in India" carried out in this laboratory. The methods used were similar. The relative weekly growth-rate is studied in terms of increase in dry weight expressed as percentages and calculated according to V. H. Blackman's formula of Compound Interest Law on an exponential basis. Careful comparisons are made of the respiratory indices and growth-rates of the entire plant and of its part with percentage leaf-weight and leaf-area ratios during successive periods of growth. While confirming in general the results obtained on Cotton or Balsam the present series differs in many respects, throwing interesting light on the mechanism of growth. In the first instance the Radish differs materially from the Cotton in storing an abundant supply of plastic food material for the growth and

upkeep of the plant. The special point of inquiry in this series of researches was to examine and follow critically the growth-rate and respiratory values in a plant like the Radish and see if the reserve plastic material which is supposed to be above the limiting value, introduces any marked change in the metabolism of growth in any way.

36. Experimental researches on the growth of tropical plants, Part II :—Seasonal variations in the growth-rate and respiration in relation to leaf-area and leaf-weight ratios throughout the life-cycle of the Radish plant.

Bhola Nath Singh *and* V. V. Apte, Benares.

Seeds of the same variety of Radish were sown under field conditions in different seasons of the year and observations similar to those described above in Pt. I of this series of researches were followed throughout the life-cycle during successive periods of growth rates. The results are in general in conformity with those obtained in Pt. I, except that the vegetative period becomes shorter and the flowers are produced comparatively earlier as the time advances from the rainy season onwards. The values of the growth-rate as also those of the respiratory indices tend to start initially with the maximal outburst although the intensity of either the growth-rate or the respiration tends to decrease with the advance in season.

37. Ontogenetic drifts in the photosynthetic activity of the foliage leaves of the Radish plant.

Bhola Nath Singh *and* Krishna Kumar, Benares.

The methods used in the course of the present study are similar to those used by Prof. R. S. Inamdar and communicated to the meeting of the Indian Science Congress on more than one occasion. The same temperature was used throughout the investigation and the light intensity and the Co_2 supplied to the assimilating leaves were always above the limiting value. It is concluded that the photosynthetic activity starts with a sufficiently high value, reaches a maximum before the maximal outburst of either the growth-rate curve or the respiratory index curves and then suddenly comes down after the production of the reproductive organs. The assimilatory values are calculated both according to the leaf weight as well as according to the leaf area of the leaf.

38. Researches on the chemistry and physiology of tropical plants.—Part I :—A critical study of the carbohydrate analysis in plant organs.

Bhola Nath Singh, T. S. N. Singh *and* Balwant Singh, Benares.

Prior to the actual quantitative determinations of the carbohydrates present in the plant organs a critical analysis of the different standard methods often used in such an investigation is made. From an examination of these methods it is concluded that no one method is singly suited for the estimation of all the different carbohydrates. Such a critical study is made use of in the further analysis of carbohydrates present in plant organs.

The first author wishes to record his grateful thanks to Prof. R. S. Inamdar for his helpful suggestions and stimulating criticisms in the present study and also to Prof. P. S. Varma of the chemistry department for his help and advice in the practical details.

39. Part II.—The rôle of the carbohydrate-nitrogen balance throughout the ontogeny of the radish plant.

Bhola Nath Singh, Balwant Singh *and* T. S. N. Singh, Benares.

The paper deals primarily with a quantitative bio-chemical analysis of the different carbohydrates present in the shoot and the root of the radish plant throughout the life-cycle during successive periods of growth-rate. A comparison is made of the relation of the various carbohydrates amongst one another in both the shoot and the root separately and the significance of the carbohydrate balance between the two organs is discussed. A simultaneous analysis is also carried out of the total nitrogen-content in the two organs separately and a quantitative relation between the nitrogen content in both the shoot and the root is obtained. Finally the rôle of the-nitrogen-carbohydrate-nitrogen balance is discussed with particular reference to the age of the plant. Besides the above observations a discussion of the moisture-content in relation to the carbohydrates and nitrogen is also included.

The above chemical analysis was carried out in conjunction with a parallel record of the growth-rates, respiratory indices, and assimilation of the leaves throughout the life-cycle of the plants belonging to the same series and grown under identically similar field conditions. The first author's thanks are due to Prof. P. Parija for his valuable criticisms.

40. The influence of light and darkness upon growth, development and reproduction in *Vicia faba*, *Avena sativa* and *Helianthus annus*.

H. Chaudhuri, Lahore.

Seeds of the above mentioned plants were germinated in a large number of pots. One set was grown in light-proof card-board boxes, made specially for the purpose, others being placed in a room with arrangement for diffused light only. They were examined every night in ruby light, when the pots were watered and daily growth measurements taken. The relative growth of the plants is given. It is found that Vicia and Avena grow more in length in darkness while in Helianthus more growth in length takes place in diffused light than in darkness.

The set of plants grown in diffused light became green as they developed and their response towards one-sided illumination was noted. Avena was found to be most sensitive to light and Helianthus was the last to respond to light.

Out of the plants grown in complete darkness, a set of plants was exposed to artificial light from a 50 C.P. Zeiss reflector lamp for 20 secs. daily at a distance of 4 feet when the seedlings had grown for an inch or more. The effect of these short exposures was very marked on Avena. After five exposures these plants were all almost green. Vicia became distinctly yellowish. But little or no effect was found on Helianthus.

These plants which were grown under three separate conditions viz., (1) exposed to short light exposures, (2) grown in complete darkness, (3) grown in diffused light, were now exposed for 30 minutes to one-sided illumination. Avena responded in those cases where the plants were grown in diffused light and where plants were partially exposed to light. Similar results were obtained with Vicia but not so marked in plants partially exposed to light. In Helianthus no response was found in plants partially exposed to light. Plants grown in diffused light responded readily. In no cases response to light was found in fully etiolated plants.

The time of exposure in diffused artificial light in Helianthus was next increased to one minute everynight and after five exposures the plants became yellowish. These were then exposed to one-sided illumination for 30 minutes with no result.

After a fortnight of starting the experiments, Vicia and Helianthus grown in light, partial light and in complete darkness were all placed outside the room. Of the plants grown in complete darkness only a few could survive. Vicia grown in complete darkness that could withstand daylight, produced flowers and pods in a week's time and those grown in partially exposed light flowered and fruited earlier than the plants grown in diffused day light. Vegetative growth in plants grown in darkness was almost nil after being placed outside, while plants grown in diffused day light grew on merrily and produced flowers and fruits much later. In Helianthus though the plants grown in complete darkness and those partially exposed, did not flower and fruit so quickly as Vicia, yet flowered much earlier than the plants grown in diffused day light.

41. Chlorophyll from Indian plants. The relation between the chlorophyll content and water content in leaves in different stages of growth.

R. H. Dastur *and* N. A. Buhariwalla, Bombay.

In a contribution made by the writers last year a spectroscopic method to determine the quantity of chlorophyll from one single leaf was described. By this method the chlorophyll content of leaves in the different stages of growth is determined. The water content of the leaves is found by the difference in the wet and dry weights of each leaf. Such determinations have been made from the leaves of a number of the sun and shade plants. The results obtained with the leaves of two plants are given. The leaves are taken from the same branch in successive order from the apex to the base, the youngest leaf being nearest the apex and the oldest one nearest the base.

All the plants so far investigated have yielded similar results.

The results indicate that as a leaf grows its chlorophyll content increases and there is also an increase in its water content. In the old leaves the chlorophyll content falls and there is a fall in the water content. The fall in the chlorophyll content is due to the decomposition of chlorophyll caused by the shortage of water supply. The results obtained here, explain the irregularities of the results of Willistätter and his pupils on the relation between the chlorophyll content and the rate of photosynthesis in leaves. They also support the view recently expressed by one of the writers that the water content of a leaf greatly influences its rate of photosynthesis.

42. Determination of the effect of season on the growth of the rice crop at Karjat.

R. K. Bhide, Poona.

To determine the effect of season as distinct from the effects of soil and other things it is necessary to know the average behaviour of the crop under fairly uniform soil conditions for several years. At the Rice Breeding Station, Karjat, attempts were made to have the soil and the other factors fairly uniform from year to year. But the climatic factors were naturally beyond control.

The following characters of several strains of the Kolamba rice were studied in detail from 1921 to 1925. But special reference is made here only to the behaviour of strain No. 42 which is now being distributed to the cultivators as a high yielding strain of pure ancestry, and reference is made to the behaviour of other strains in a general way only. The

characters studied were : (1) Dates of flowering, (2) No. of fertile tillers, (3) Height of plants, (4) Length of the main panicle, (5) No. of spikelets in the main panicle, (6) No. of sterile spikelets in the main panicle, (7) Yield of the main panicle and (8) Yield per plant. Of these characters, tillering, yield and sterility may be said to be affected by season appreciably.

As the probable effect of soil and other conditions of growth from year to year were known, proper allowance could be made for these, and the influence of season on the behaviour of the crop in those years could be easily inferred. This was done by averaging the figures for the five years and by finding the ratio of difference between the average and the yearly figure, to error in the case of the various characters. Along with this a study of the rainfall figures was also made for the five years and the probable effect of the rainfall at particular stages of growth was compared with the behaviour of the crop in regard to the various characters in the light of the current belief of the cultivators. Thus a fairly close relation of the favourable and unfavourable condition of the season could be established with the actual behaviour of the crop from year to year. This was supported by the combined graphs (both actual and theoretical) of the various characters for five years.

43. The influence of definite doses of sugar on respiration of leaves.

Shri Ranjan, Allahabad.

Work of this kind has been done by many investigators. All the previous workers put their nutrient solutions in the same chamber with the leaves and this always caused bacterial infection, the effect of which brought in experimental error in about 40 hours. A new method has been tried to remove this difficulty which is briefly as follows. The leaves to be injected are put in a particular chamber containing the desired nutritive substance. The air is then evacuated from the leaves. When the evacuation is complete the air is let in and liquid surrounding the leaves gets injected.

The experiments dealing with the effects of sugar solutions on the rate of respiration of leaves are given. It has been found when sugars are injected the respiration goes up but within a short time, e.g. before all the solution is exhausted it climbs down. This shows that a part of the sugar is converted into something else. The problem of finding out the particular substance into which it is converted is being tackled by Mrs. Onslow at Cambridge.

It has also been shown that the life of a leaf can be lengthened by injecting suitable amounts of sugars into it.

44. The root habits of a xerophytic plant community.

P. M. Somasundaram, Bangalore.

A description of the characters of the root system of plants, about thirty, very commonly found in a dry rocky locality in Bangalore.

45. The aquatic vegetation of Bengal, in relation to supply of oxygen to water.

Kalipada Biswas, Calcutta.

In this paper the author gives a brief account of the common aquatic plants of Bengal as they are distributed in the lakes, tanks and ponds. An ecological classification of these plants with reference to the function of supplying oxygen to the water has been suggested. A list of the aquatic plants of Bengal has been added for the convenience of the

pisciculturists as they may want to grow a particular type of submerged vegetation for proper aeration of the water in which they cultivate fishes. This paper forms a counterpart of the paper on "Investigations regarding an epidemic of fish mortality in the tank in the Indian Museum compound," read before the monthly meeting of the Asiatic Society of Bengal, on the 8th of July, 1925, by Major R. B. Seymour Sewell, Director, Zoological Survey of India.

46. The *Shorea robusta* forest of Bhowal in Dacca.

H. K. Datta, Dacca.

The forest is tropophilous, with a wet summer, and dry winter when the humidity falls to 0·55. The mean summer temperature is 84°F. and Winter temperature 65°F. The annual rainfall varies from 61″ to 82″. The soil is red laterite soil, poor in lime and phosphates, and the ground is undulating, composed of elevations and depressions like that of the Ghats of Chotanagpur. The flora is allied to that of Chotanagpur and many plants of Hill-Tippera, Chittagong and Garo Hills are found there. The dominant species is *Shorea robusta*, and next to it the most conspicuous species is *Spatholobus Roxburghii*, a liane. *Vitis repanda* is another robust climber often met with. An account of the trees forming the second tier in the forest, undershrubs which form part of the ground vegetation, herbs forming the ground vegetation, and parasites, is given. The trees, shrubs, herbs and climbers, growing in the margins and clearings are also mentioned.

47. A short note on parthenogenesis in Cotton.

R. Balasubrahmanyam, Madras.

The pollen of *G. hirsutum* supplies the necessary initial stimulus for the growth of the ovary till the 19th day when the growth of boll is almost over.

A critical period is existent at about 20th day.

The growth of bolls up to the day of shedding agree with the normal.

A small percentage of parthenogenesis is present in *G. indicum* (N_{14}).

The bolls are smaller than normal bolls and contain fewer number of seeds.

48. The inheritance of purple pigmentation in *Eleusine coracana*.

G. N. Rangaswami Ayyangar *and* P. Krishna Rao.

Three colour types—Purple, Light Purple and Green—are noticed in this cereal. Two factors, one for Pigmentation and another for Intensification, are concerned in the production of these three types, the Purple being due to the presence of both factors, Light Purple to the purple factor only and the Green throughout lacking the Pigmentation factor. A cross made between a Light Purple and a Green throughout with the intensification factor, gave a Purple, corroborating this theory.

49. The science of botany in ancient India.

G. P. Majumdar, Calcutta.

The author, with the help of quotations from ancient texts such as, Rigveda, Atharvaveda, Arthaśāstra, Charaka, Vrihatsamhita, Agnipurana, etc., seeks to establish the existence of a science of botany in ancient India which had, then even as now, to be studied as an indispensable preliminary by the votaries of medicine as well as agriculture.

50. An improved type of cotton for Khandesh.

S. H. Prayag, Dhulia.

Khandesh forms one of the great cotton growing centres in the Bombay Deccan. The bulk of the cotton grown is, however, short stapled. Attempts to improve this cotton date as far back as 1831, but the serious attempts commenced since 1905. The methods adopted were

(1) Introduction of indigenous and exotic varieties
(2) Isolation in the existing varieties
(3) Hybridisation.

The first method proved unsuccessful as the season of Khandesh was found to be too short for such cottons. As a result of the second method a variety known as N. R. was evolved, which possessed the desirable qualities of yield and ginning out-turn, besides being early. It was also found to be capable of resisting drought, so common in Khandesh. It thus gained popularity but the staple was found to be coarse, besides being short. In this paper an attempt is made to describe a segregate from the supposed cross between Bani and Commilla, made several years ago. The original material B XX, from which the present type of B XX 27, has been evolved was found to consist of a number of biotypes. Rigid selection and purification work started since 1921. As a result of this, a number of types have now been maintained for one or other desirable characters. In the present paper, the behaviour of the strain B XX 27, as regards yield, ginning percentage, and staple has been given, for a number of years. It was found to meet the requirements of Khandesh conditions viz. earliness, drought resisting capacity and high yield, and high ginning percentage. In addition, it has been found to be superior to N. R. in point of staple both in feel and in length and capable of spinning up to 20's, (N. R. spinning up to 10's). Unlike N. R., the leaves of this strain have no accessory lobes. The flowers of this strain are pale yellow or sulphur-white in colour, those of N. R. being white, thus facilitating purification work. The area grown under this crop during the year is about 100 acres, to be increased to 1,000 acres next year. Its purity is being maintained by the growing of selfed seeds every year.

Section of Geology.

President:—L. Dudley Stamp, B.A., D.Sc.

Presidential Address.

The oil fields of Burma: recent advances in geological knowledge.

It is very difficult for me adequately to express my appreciation of the great honour paid me by my geological colleagues in India in electing me to the Presidential Chair of the Section of Geology of the Indian Science Congress. My five years in India have been spent mainly in the province of Burma and my geological studies have been largely in that province and in the neighbouring territory of Malaya. My acquaintance with the remainder of India is so slight that I feel myself doubly unworthy to fill this Presidential Chair. Moreover, since my acceptance of the honour, circumstances have arisen to cause my departure from India, and it is my fear that this address must be read in my absence. My own University, the University of London, has summoned me to fill a new post in the domain of geography. But nearly five of the best years of my life have been spent in India and those years have served to develop an undying interest in Indian Geology and Geography. In the future it will be my constant endeavour to promote a closer contact, a deeper and more lively mutual appreciation of the work of my Indian colleagues and the geological fraternity in Europe. It is the privilege of the President on such occasions as these to survey one of the broader aspects of his subject. I propose, therefore, to devote the present occasion to a consideration of the progress which has been made in recent years in the study of the Tertiary geology of Burma.

A very close rival to coal, petroleum forms the second most important mineral product of India. Of the total produced in India by far the largest quantity comes from Burma and the Province has, for many years past, had an annual output of roughly 275,000,000 gallons of crude oil, valued at over seven crores of rupees. All the oil of Burma comes from the tertiary rocks. No excuse, therefore, is needed for treating in this address with the Tertiary geology of Burma, more especially as the greater part of my five years in the country has been occupied in their study.

The publication, in 1912, of Dr. E. H. Pascoe's memoir, "The Oil Fields of Burma," forms a great landmark in the history of Burmese geology. I propose to confine myself to a consi-

deration of work which has been carried out since that time. So far as published work is concerned, by far the largest proportion is due to the activities of the officers of the Geological Survey of Burma, special prominence being given to the names of Dr. G. de P. Cotter and the late Mr. E. W. Vredenburg. Amongst others Dr. Murray Stuart, the late Mr. H. S. Bion and the late Mr. F. W. Walker, Mr. Sethu Rama Rao, Mr. M. Vinayak Rao and Mr. E. L. G. Clegg have been actively engaged in mapping.

Amongst the oil companies, the period 1912 to 1926 has been one of ceaseless activity. It would scarcely be an exaggeration to say that the whole of the Tertiary Basin of Burma has been carefully mapped on the one-inch scale, and very large areas on six-inch and eight-inch scales. The geologists of the oil companies have, perforce, paid special attention to the mapping of lithographical horizons ; the Peguan in particular, has been separated locally into lithological groups. The lithological horizons, despite the fact that they change in character when traced laterally, are of the greatest importance in oil-geology. The oil companies have spent vast sums on geological survey work and have been, therefore, rather unwilling to give away the results obtained by immediate publication. Only small fragments of all this work have accordingly been made public.

Independent or amateur geological observers in Burma are so few as to be almost unknown Dr. Stamp and Mr. H. L. Chhibber of the University of Rangoon may be regarded as falling into this category.

The general geology of Burma.

The general geology of Burma is relatively simple and the country may be divided into four parts.

(1) The eastern massif of old rocks. The whole of the east of the country, including the Shan States and Tenasserim. consists of a massif of hard old rocks varying in age from Pre-Cambrian to Jurassic. The whole area, with the exception of a number of old lake basins, has probably been land since the latter part of the Mesozoic. The massif forms a plateau with an average elevation of 3,000 feet. The western edge is clearly defined, being marked by the conspicuous line of hills familiar to every traveller by train from Rangoon to Mandalay. Along this line the Tertiary rocks dip sharply away from the old massif, but the junction is rarely visible.

(2) The western fold ranges. In the west of Burma the dominating feature is a great range of fold mountains. The range is complex and broad in the north where it comprises the Naga, Chin and other groups of hills, but southwards it narrows to form the Arakan Yoma. The actual physical structure terminates in Cape Negrais but structurally the same fold

continues through the Andaman and Nicobar Islands into Sumatra. In Burma several peaks reach 10,000 feet. Very little is yet known of the geology of the range. The structure appears to be anticlinorial with a central core of crystalline rocks. Triassic, Jurassic and Cretaceous rocks are involved in the folding as well as the Tertiary sediments. There is good reason to believe that the fold originated in Cretaceous or earlier times and grew gradually during the alpine movements of the Tertiary period. The fold gave rise to a narrow land barrier from Eocene times onwards.

(3) The Central Tertiary Basin. Between the Arakan Yoma on the west and the Shan Plateau on the east lies the great region of Tertiary rocks in Burma. It corresponds roughly with the basins of the Chindwin-Irrawaddy and the Sittang Rivers, and it is with this region that the present address is primarily concerned.

(4) The Arakan Tertiary Region. Between the Arakan Yoma and the Bay of Bengal lies another area of Tertiary rocks forming part of the Assam area of deposition. We shall not consider that area here.

The Tertiary geography of Burma.

In early Tertiary times Burma may be pictured as partly covered by a long narrow gulf of the sea, with the Shan Plateau forming the land mass on the east and the central ridge of the Arakan Yoma forming a narrow strip of land on the west. The gulf would be broader than appears at the present day owing to the extensive lateral compression and folding which has since taken place. The gulf was open to the sea to the south but into the northern end there poured one or more great rivers. Possibly the Tibetan course of the Brahmaputra is a remnant of this river; at a later stage rivers of which the Chindwin and the Irrawaddy are the modern representatives, took its place. The whole history of the Tertiary period in Burma may be summed up as the story of the infilling of this gulf by river-borne sediments from the north and by marine sediments in the south. On the whole, therefore, there has been a spread of continental deposits from the north, pushing the marine waters further and further south. This process is still going on, for year by year the delta of the Irrawaddy encroaches on the shallow Gulf of Martaban.

The conception of this great fundamental idea underlying the Tertiary geology of Burma is due to Dr. G. de P. Cotter.[1]

The gradual infilling of the trough has, however, been interrupted at intervals by lateral folding movements. These

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[1] Cotter The Geotectonics of the Tertiary Irrawaddy Basin, *Journ. Proc. Asiat. Soc. Bengal*, vol. XIV, 1918, pp. 409–420.

movements resulted in the gradual uplift of the Arakan Yoma and, at a later stage, of the Pegu Yoma and other folds. Each movement of folding however, caused a temporary increase of the depth of the centre of the basin and a consequent return northwards of marine conditions. Thus it is found that the gradual southward retreat of the sea was interrupted by temporary northward movements which have left their mark as wedges of marine strata tailing out northwards. This development of Cotter's ideas was brought out by Stamp's work in the Chindwin[1] and was embodied by him in a generalisation referring to the whole Tertiary region of Burma.[2]

Since then, it seems to have been generally acceptable to geologists[3] and Stamp has adduced further evidence.[4] Dr. Murray Stuart also concurs except that he considers the Burmese and Assamese Gulfs were joined at their northern end and that the Arakan Yoma formed an island rather than a peninsula.[5]

The Tectonics of the Tertiary Belt of Burma.

Considered as a subject apart, very little has been published on the tectonics of the Tertiary Belt. A considerable amount of material now exists on the one-inch maps surveyed geologically by the Geological Survey of India.

Recent work (unpublished) by several geologists in several localities has all tended to prove that the junction between the Tertiary rocks and the Shan Plateau massif is a normal one and not faulted. Cotter (*op. cit. sup.* Australia, 1924) has already noted this necessary correction of Stamp's summary (*op. cit. sup. Geol. Mag.* 1922).

The general character of isolated folds in the centre of the Tertiary basin is already well known, having been considered in detail by Pascoe. It is characteristic of the folds that they are elongated domes, drawn out parallel to the length of the old gulf and parallel to the Arakan Yoma, with a gently sloping western limb and a steep, usually overfolded and faulted, eastern limb.

Stamp's very brief summary of the tectonics of the Tertiary belt,[6] written early in 1922, contains little of importance

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[1] Stamp, Geology of Part of the Pondaung Range, Burma. *Trans. Mining Geol. Inst. India*, Vol. XVII 1922, pp. 163–180.

[2] Stamp, An Outline of Tertiary Geology of Burma, *Geol. Mag.* Vol. LIX Nov., 1, 1922, pp. 481–501.

[3] Cotter, Proc. Pan-Pacific Congress, Australia, 1923. Cotter, The Mineral Deposits of Burma. *Supdt. Govt. Printing, Rangoon*, 1924; Coggin Brown, *Rec. Geol. Surv. Ind.*, Vol. LVI, pp. 65–108.

[4] Stamp, *Geol. Mag.* Vol. LXII Nov. 1925, pp. 515–528.

[5] Stuart, *Journ. Inst. Petrol. Technologists*, Vol. XI No. 50, and *Rec. Geol. Surv. Ind.*, Vol. LIV, part 4, 1923.

[6] Stamp, *Comptes Rendus XIIIe Congr. Géol. Internat*, Bruxelles, 1922 Fasc. II (1925).

and requires the same corrections as the 1922 paper above. It may be of interest to add a few brief notes on recent work still unpublished. When fully worked out the Pegu Yoma fold complex will afford an interesting study. It seems to consist essentially of a tightly packed bunch of folds which splay out northwards, rather after the manner of a wheat-sheaf which has been tied tightly about the lower part. On the western flanks, some of the folds branch off from the main mass and before pitching away northwards and dying out, become separated from the main mass by a considerable area of horizontal strata. A good example is afforded by the Paukkaung fold, crossed by the road from Prome to Paukkaung, about the 29th mile. On the east, the highly folded Tertiaries of the Pegu Yomas approach very closely to the Shan Plateau massif, from which they are separated solely by the relatively narrow alluvial tract of the Sittang valley. This is the case in the Pyu Chaung, where the most easterly tertiary rocks seen are highly folded. The railway cuttings along the line from Pyinmana to Taungdwingyi gave a good opportunity for studying the complex folding of the Pegu Yoma.

Our knowledge of the folding of the eastern flanks of the Arakan Yoma is still very inadequate. It is probable that strike faulting plays an important part.[1] It has recently been claimed that important thrust faults exist in the Yenanma region of the Thayetmyo District,[2] but has been strenuously denied in public by Mr. Dewhurst of the Burmah Oil Co. Ltd.[3]

The Lithology of the Tertiary Rocks of Burma.

The Tertiary rocks of Burma range from coarse conglomerates through sands and sandstones to bedded shales and rubbly shales and clays. The freshwater deposits are, as a rule, fairly distinct from the deltaic and marine ones, and it may be useful to note briefly the principal types.

Freshwater Deposits.

(1) Coarse quartzose sands, usually false-bedded, are the dominant type. The bulk of the "Irrawaddian" rocks have this character. The sands are but rarely consolidated. In most sands of this type, at various horizons in the Tertiary sequence, silicified wood is found and occasionally fossil bones.

(2) Conglomerates, usually of pebbles of vein quartz and frequently consolidated by a ferruginous cement, occur associated with the sands, especially at the base of the various

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[1] Stuart, *Rec. Geol. Surv. Ind.*, Vol. XLI, 1912, pp. 240–265.

[2] Stuart, *Journ. Inst. Petrol. Technologists.* Vol. XI, No. 52, pp. 481-5—(1925).

[3] At a meeting of the Institution of Petroleum Technologists, London, Oct. 19th, 1926.

freshwater series. Rolled pebbles of silicified wood are common, as well as remains of turtles, crocodiles and mammals. Frequently the ferruginous conglomerates pass laterally into "red-beds." These red-beds are of the nature of laterites and may represent old land surfaces. The most famous red bed occurs at the base of the Irrawaddian in the region of the great oil fields. Another well marked one occurs at the top of the Pondaung Sandstones in the Lower Chindwin.

(3) Pale grey clays, of the nature of pipe clays and with all the characteristics of freshwater clays in other parts of the world occur as thin lenticles amongst the sands.

(4) Mottled clays, occuring as much thicker beds, are characteristic of certain horizons. They are usually mottled in pale green and purple, and are especially noteworthy in the upper part of the Pondaung Sandstone and in the Kyabin Clay Group of the Chindwin. They are the frequent receptacle of fossil reptilian and mammal bones[1] and are often associated with beds of pure white sand. In some cases (coal series of the Upper Chindwin), there are similar but brownish and yellow clays. As a rule the mottled clays exhibit little or no evidence of bedding.

Deltaic and Marine Deposits.

Stamp has already studied in some detail[2] the lithology of these beds and has noted that they vary as follows :—

C—Homogeneous unbedded clay, often rubbly.
cc—Banded sediments, almost entirely clayey.
c—Banded sediments, clay predominating.
s—Banded sediments, sand predominating.
ss—Banded sediments, almost entirely sandy.
S—Homogeneous sand, often false-bedded.

In this paper Stamp has discussed the significance of the banding seen in the sediments, considering it due to annual floods of the ancient Tertiary river. Each double band of coarse and fine sediment represents the deposits of a single year. By counting the number of laminæ it is shown that the Peguan period occupied more than 2,000,000 years.

The lithological succession of Tertiary rocks.

From what has been said regarding the change from a completely freshwater facies in the extreme north to an almost

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[1] Pilgrim and Cotter, *Rec. Geol. Surv. Ind.*, Vol. XLVII, pp. 42–77.

[2] Stamp, Seasonal Rhythm in the Tertiary Sediments of Burma, *Geol. Mag.* Vol. LXII, Nov. 1925, pp. 515–523. Abstract in *Report Brit. Assoc.*, 1925.

completely marine one in the south, it is obvious that there must be great variation in the lithological succession.

The Tertiary sediments infilling the gulf are usually divided into three great groups :—

Irrawaddian (Mio-Pliocene)
Peguan (Oligo-Miocene)
Eocene.

The Eocene Beds are exposed mainly down the western margin of the old gulf. They are as yet imperfectly described but reach an enormous thickness—not less than 12,000 feet in measured sections. The sequence about Lat. 22° N. is :—

Yaw Shales (marine).
Pondaung Sandstones (freshwater in upper part, marine below).
Tabyin Clays (marine).
Tilin Sandstones (partly freshwater ?)
Laungshe Shales.
Paunggyi Conglomerate.

At times the Paunggyi Conglomerates rest unconformably on various older rocks, but at other times there is an extensive series of lowest Eocene Shales underlying them.

In the south of Burma the Eocene sequence is largely argillaceous and bands of nummulitic limestone occur.[1]

The Peguan and Irrawaddian are to some extent complementary. The Irrawaddian is a fluvio-lacustrine series decreasing in importance southwards, i.e., towards the seaward end of the gulf. The Peguan or Pegu Series of Theobald (1870) despite various interpretations which have been given to it, may be defined as including all the post-Eocene and pre-Irrawaddian rocks of Burma. It is entirely marine in the south but passes northward into continental types of deposit (continental Peguan). The marine Peguan is almost everywhere divisible into three broad lithological groups which have no reference to time horizons :—

(iii) An upper mixed sandy and shaley group, including the Lower and Upper Prome Beds (with the Kama Clay) of Lower Burma, the upper sandy or mixed groups of Thayetmyo and Minbu Districts ; and the exposed Pegu rocks of the oil fields of Yenangyaung, Singu and Yenangyat (at least the higher beds.)

(ii) A middle group of rubbly, non-sandy shales, Sisayan

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[1] A very large area along the western borders of the tertiary region has been mapped in recent years by Mr. E. L. G. Clegg. No detailed account of his work has yet been published, but brief notes of his results are given in the annual Reports of the work of the Geological Survey. The dying out of the sands groups southwards is particularly in evidence.

Shales of Lower Burma, decreasing in thickness northwards and passing into the Padaung Clays.

(i) A lower sandy or mixed group, comprising the Shwezetaw Sandstone of Upper Burma. The group becomes less marked southwards and eventually disappears.

At the base of the Peguan is found the Kyet-u-bok bed which may be regarded as the top of the Eocene or as the base of the Peguan. Northwards it is the Padaung Clay which remains marine for the greatest distance but eventually passes into the freshwater Kyabin Clay Group of the Chindwin. The broad threefold division of the Peguan was recognised by Cotter.[1]

The palæontological horizons of the Tertiary of Burma.

The upper Eocene lamellibranchs (mainly of the Yaw Stage) have been adequately studied by Cotter.[2] The study of the rich Peguan faunas of gastropods was undertaken by Vredenburg.[3] Geologists in Burma will ever be under a great obligation to Vredenburg for his painstaking and brilliant palæontological work.

To Vredenburg belongs the credit of establishing a succession of stages, based on his studies of marine faunas.[4] It has been said that Vredenburg was unfortunate in that most of his material came from the isolated inliers of the oil fields and not from the continuous exposures of the western border, but recent work tends to confirm most of Vredenburg's conclusions. He established six stages :—

6 Akauktaung Stage
5 Pyalo Stage
4 Kama Stage
3 Singu Stage
2 Padaung or Sitsayan Stage
1 Shwezetaw Stage.

Stamp (1925) has confirmed Vredenburg's succession with certain modifications. He has shown that the Pyalo stage does not exist and he has tentatively inserted a "Migyaungye

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[1] Cotter, *Rec. Geol. Surv. Ind.*, Vol. XLI, 1912, pp. 221–239 see also Porro, *ibid.*, Vol. XLV, 1915, pp. 249–270. Cotter, *Rec. Geol. Surv. Ind.*, Vol. XLIV, 1914, pp. 163–185.

[2] Cotter, The Lamellibranchiata of the Eocene of Burma. *Pal. Ind.* 1922., On the Value of Nummulites as Zone Fossils. *Rec. Geol. Surv. Ind.*, Vol. XLIV, 1914.

[3] Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. LI. 1920, pp. 224–302 ; Vol. LIII, pp. 83–129 ; pp. 130–141 ; Vol. LIV, pp. 243–276 ; Vol. LV, pp. 52–77 ; 110–118 ; 119–132.

[4] Vredenburg and Prashad, *Rec. Geol. Surv. Ind.*, Vol. II, 1921, pp. 371–4 Vredenburg. *Rec. Geol. Surv. Ind.*, Vol. LIII, 1921-2 pl. XXV ; pp. 321–342 ; pp. 359–369.

Stage" between the Singu and Kama Stages, at the same time reserving judgement on the Akauktaung Stage (which is only developed in Lower Burma) until further study has been made. His succession therefore stands :—

5 Kama Stage
4 Migyaungye Stage
3 Singu Stage
2 Padaung Stage
1 Shwezetaw Stage

Some of the evidence for this revised grouping has been given.[1]

The key to the understanding of the Peguan succession is the recognition of the fact that the palæontological horizons cross the lithological horizons. This has been recognised by many workers in Burma and is brought out in the 1925 paper of Stamp.

The oil geology of Burma.

Of recent years this aspect of the subject has received considerable attention. Murray Stuart[2] in a succession of papers has urged the importance of Dipterocarp wood as the source of the oil, but somewhat unnecessarily supposes that the Dipterocarp forests must have been growing on the Arakan Yoma island. He rather ignores the widespread occurrence of fossil wood in the freshwater Peguan of northern Burma, and considers the wood from which the oil is derived is that found silicified in the Irrawaddian. He also discusses the connexion between coal and oil.

Studies on the occurrence of oil have been made by Bleeck,[3] (detailed account of the Minbu fold), K. K. Sen Gupta[4] (who suggests repetition of oil sands in the Sengu-Yenangyat anticline by recumbent folding) and A. S. Subbaiyer.[5]

Stamp[6] has recently traced the connexion between the oil bearing horizons, the change of lithology and palæontological horizons. He has expressed the results in diagrammatic form and finds that the oil-bearing beds change their horizons when traced laterally but are always associated with intermediate conditions

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[1] Stamp, Conditions Governing the Occurrence of Oil in Burma. *Journ. Inst. Petrol. Technologists*, (in the press).

[2] Stuart. *Journ. Inst. Petrol. Technologists*, Vol. XI, No. 50 (1925), Vol. XI, No. 52 (1925), Vol. XII, No. 56 (1926) also "The geology of Oil and Oil Shale" London, 1926.

[3] Bleeck, *Trans. Mining Geol. Inst. Ind.*, Vol. IX, 1915, pp. 61-73.

[4] Sen Gupta, *Twelfth Indian Science Congress*, Benares, 1925.

[5] Subbaiyer, *Thirteenth Indian Science Congress*, Bombay, 1926. In one of the three papers read on this occasion, the statement is made that the Sitsayan Stage beds embrace all the known post-Eocene oil horizons of Burma. This conclusion is at variance with those reached by most oil geologists in Burma.

[6] Stamp, *op. cit. sup.* (in the press).

of deposition—never with freshwater beds and never with deep water marine beds.

An important study of the late Tertiary igneous rocks of Burma has been carried out by Chhibber, and his work has finally exploded the theory that there is a connexion between the vulcanicity of Burma and the formation of oil or between the vulcanicity and the silicification of the well-known fossil wood of the Irrawaddian.[1]

Since Pascoe wrote his memoir, much has been done in Burma, but very much more remains to be done. The Geological Survey are steadily completing the mapping of the Tertiary tract and accumulating the material for a full study. A special commendation is due to the workers in the field who, until their task is finished, can only have their maps as a record of much arduous work. Much also remains to be done in completing Vredenburg's unfinished palæontological studies. Detailed tectonic studies of special areas are greatly needed before any synopsis of the tectonics can be given. Burma is capable of yielding much more information towards the solution of that most elusive of problems—the origin of oil.

If this short address has served to arouse some interest in the problems presented by the Tertiary rocks of Burma and the desirability of further study of this great oil-bearing series, it will have achieved its purpose.

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[1] Chhibber (with Stamp). The Igneous and associated rocks of Kabwet (Upper Burma); Pinfold, Day, Stamp and Chhibber. The Late Tertiary Igneous Rocks of the Lower Chindwin Area; Chhibber. The Petrography of Mount Popa; Chhibber, Late Tertiary Intrusive Rocks of the Pegu Yomas. *Trans. Mining Geol. Inst. India.* 1925 onwards.

Abstracts of Papers.

1. On two types of fossil wood from the Utatur Cretaceous, Trichinopoly District.

KHAZEE MOHAMED AHMED, Trichinopoly.

The paper describes two interesting types of fossil wood collected from the Utatur formation—with special reference to their structure as examined under the microscope. The first type is recognised as belonging either to the *Bucklandian* type of *Cycadian* stems (as described by Seward) or to the *Araucarian* type of *Conifers ;* while the second appears to be the stem of a *Dicotyledon*—showing structural affinities with the two families *Ternstroemiaoœ* and *Cupuliferœ*. This latter is important inasmuch as *Dicotyledonous* fossil wood has not been recognised so far in the South-Indian Cretaceous rocks.

2. On a new type of Cassidulidæ from the Upper Cretaceous rocks near Ariyalur.

S. LAKSMANA RAO.

The paper gives a complete description of a fossil echinoid collected from the Upper Cretaceous rocks near Ariyalur. Attention is drawn to the fact that this type differs in several important characters, such as the conjugate nature of the pores in the ambulacral areas, the perforate nature of the primary tubercles, etc., from the genera so far described from the area, and must therefore be considered as a new type of *Cassidulidœ*, allied to but not identical with *Stigmatopygus*, *Cassidulus* and *Pygorhyncus*.

3. Stigmatopygus vs. Cyrtoma, a discussion in nomenclature.

L. RAMA RAO, Bangalore.

In connection with the detailed study and description, now under progress, of a collection of fossil echinoids from the Upper Cretaceous rocks near Ariyalur, the present paper deals with the generic significance of two of the forms described under the names *Stigmatopygus* D'Orb, and *Cyrtoma* M'Clelland. It has been shown that the two genera do not overlap, as was suggested sometime back by Prof. H. C. Das-Gupta, but are quite distinct, so that neither of them could be rejected from the generic names of the fossil echinoids found in the Upper Cretaceous beds of India.

4. Kyanite from Nellore.

V. S. SWAMINATHAN, Madras.

Kyanite forms a prominent constituent of the Archean schists exposed :—

(1) at Kandli near Gauri and Sankara mines, with quartz, garnet, and mica.
(2) on the eastern flank of Devarakonda, half a mile west of Saidapuram.
(3) near the tank weir at Kalichedu.

(4) west of the Incurti mine on the high ground.
(5) opposite the village Narasimha Kandrika, 3 miles W. N. W. of Podalakur.

Samples from localities 2 & 5 seem to be attractive from an economic point of view.

At Devarakonda, huge boulders and rocks *in situ* are exposed, the quartz-kyanite rock running in a N-S direction for a distance of half a mile. The average width is from 108—150 yards. Kyanite forms the major portion of the rock varying from 65—80%. The hillock is from 100—120 feet high.

Fairly long and wide parallel bands of kyanite—quartz rock, almost free from garnet and mica flakes are exposed S. of Narasimha Kandrika.

Experiments conducted on natural kyanite (sillimanite ?) obtained from Singhbum for use as a refractory material (*Jour. Am. Ceramic Soc.* Vol. 9, No. 5, 1926; *Jour. Soc. Glass Tech.* Vol. 7, 248–61, 1923) have given very satisfactory and encouraging results and the Nellore deposits could with advantage be used for similar purposes.

5. Notes on the mode of occurrence and composition of Beryl from Nellore.

V. S. Swaminathan, Madras.

Crystals of beryl have been found associated with mica bearing granite-pegmatites, in the following mica mines—Anantamadugu, Kalichedu, Kelly, Kubera, Lakshminarayana and Palimitta (*vide* sketch map).

They vary greatly in size, specimens being found from a centimetre or less in diameter to more than one and a half feet. The colour of the individuals from different mines varies, also in one case—Laksminarayana—those from the same quartz. Large crystals enclosing clear fragments are not uncommon. The common prevailing colours are bluish green, apple green, greenish yellow and pale sky-blue. The pyramidal terminations in the crystals are wanting in most cases. The specific gravity varies from 2·65—2·82.

The association of the mineral with perthite (moon-stone ?) is very characteristic, as also with big bosses of quartz. In one case, the specimen is partially enclosed by a big semi-precious garnet crystal of blood-red colour.

A rough estimate of the quantity available is given, and the commercial and scientific uses of the mineral are touched upon.

6. Petrological notes on (a) granitic and gneissic rocks, and (b) quartz-augite-porphyrite from Nellore, Madras.

V. S. Swaminathan, Madras.

A. Granites and gneisses come next to schists, micaceous-and hornblendic-pegmatites and quartzites in their order of abundance. Outcrops are met with at Vedicherla, Patragunta, Marlapudi, Vadlupudi, Marupur and Narasimha Konda.

Besides, granitic modifications of pegmatites are common enough in the area and are particularly well seen in the Varadaraja mine, Mangalpur and immediately west of the village Valavarpalli, 5 miles N. of Podalakur.

These rocks have a general N-S trend.

Because of the significant proximity of many of the exposures to the mica mines (pegmatites), and occurrences of gradational forms, it is suggested that there may be a genetic connection between the granites and the pegmatites in this area.

B. The porphyrite rock is exposed in and around Monobolu rail-

way station. It is seen for a distance of 200 yards in the form of small low-lying mounds, never above 20 feet higher than the adjacent country. It has a dominant N-S trend, and is seen distinctly to intrude into the schists which form the country rock.

Analyses of the following typical rocks of the area are given in the paper :—

1. Coarse Muscovite Granite. Valavarpalli, 5 miles N. of Podalakur.
2. Micaceous garnetiferous gneiss. Tellabodu mine, Saidapuram.
3. Granite. Patragunta-South of Gudur.
4. Granitoid gneiss. Narasimhakonda.
5. Quartz-augite-porphyrite. Monobolu Ry. Stn.

7. The Rhyolites and Rhyolite Tuffs of Thaton District, Lower Burma.

H. L. Chhibber, Rangoon.

The present communication forms the fifth instalment of the series of papers on the volcanic rocks of Burma. The volcanic rocks described below are situated in the township of Sittang, Thaton district, Lower Burma. The band of lava runs for at least six miles in a north-south direction and continues on into unsurveyed territory.

The only earlier reference to this area occurs in a general report in *Rec. Geol. Surv. Ind.* Vol. XL, Pt. 2, p. 127, where a mere mention of volcanic, probably rhyolitic rocks, has been made on the basis of P. N. Dutta's investigation.

The general geology of the area consists of the following formations :—

(1) alluvium.
(2) laterite and similar earth.
(3) granite and gneissose granite.
(4) rhyolites and rhyolite tuffs.
(5) sedimentary series consisting of partially metamorphosed shales and sandstones, probably of Carboniferous age.

All these formations have been described in the paper. The origin of laterite in this area has also been described.

The volcanic rocks from their linear arrangement appear to have erupted along a fissure or fault produced probably as a result of folding and faulting of the Tenasserim Yomas.

8. The Serpentines and the associated minerals of Henzada and Bassein districts, Burma.

H. L. Chhibber, Rangoon.

The serpentines of Henzada and Bassein districts have been described in this paper; in all twenty-three intrusions occur in the Negrais and nummulitic sandstone series over a distance of 26 miles. These intrusions have been mapped on a scale of 1″=1 mile so far the maps were available. The serpentines yield very little soil and hence support a specialised type of vegetation comprising *In* (*Dipterocarpus tuberculatus*) and *Myinwa* (*Dendrocalamus strictus*).

Petrologically the intrusive rocks include wholly or partially altered peridotites, saxonites, lherzolites and dunites. Interesting types like hornblende-picrite and hornblende-eclogites have also been described from the area. Sometimes diorite (micro) occurs at the periphery of the serpentine masses. Quartz occurs in considerable quantities in the neighbourhood of intrusions and is believed to be of magmatic origin. In places the contact effects are well-marked. It has been observed that wherever the country-rock consisted of shales, it has been transformed

into schists but otherwise only hardening, baking, induration and crushing are seen when the previous rock was a sandstone.

A lode of pyrites, about 6 feet thick and in places about 40 feet wide, has been found associated with a vein of serpentine. Impure graphite also occurs, generally as a product of contact metamorphism. The coal deposits of this area are worthless.

9. The petrography of some of the Indian and Burmese slags.

H. L. Chhibber, Rangoon.

I. The old and recent Rakha mines copper slags.
II. The Tata iron slags, Jamshedpur.
III. The Mysore iron slags, Bhadrawati.
IV. The lead slags, Bawdwin, Burma.
V. The tin slags, Mergui, Lower Burma.

10. The ancient volcanoes of Burma.

H. L. Chhibber, Rangoon.

In this monograph a connected and complete account of the old volcanoes of Burma is presented.

11. On three deep-sea deposits from the Bay of Bengal.

N. N. Chatterji, Calcutta.

Three specimens—Globigerina ooze, green mud and green sand—have been analysed. Results of the analysis are discussed.

12. Fossil wood from the Lalmai Range in Comillah, Bengal.

Jyotirmaya Sen, Calcutta.

Sections of fossil wood obtained from the Lalmai range in the district of Comillah (Bengal) have been described. The wood is found to be very closely related to, if not identical with *Dipterocarpoxylon burmense* Holden obtained from Burma. From the evidence of this fossil wood the Lalmai rocks are supposed to be Pliocene in age.

13. Batrachian and reptilian remains found in the Panchet Beds at Deoli, Bengal.

H. C. Das-Gupta, Calcutta.

Part of a labyrithodont cranium, a rhynchocephalian vertebra and a theropod dinosaurian tooth are described. The labyrinthodont cranium has been referred to *Pachygonia incurvata* Huxley and the dinosaurian tooth has been identified as Teratosaurus (?) bengalensis, n. sp. A revised description of the mandible of *Pachygonia incurvata* has been discussed and a Permo-Lower Triassic age has been assigned to them.

14. Notes on the geology of the Island of Bombay.

H. C. Das-Gupta, Calcutta.

A short note dealing with the nature and origin of the rocks found at Seoree, Antop, Sion Fort Hill and Dharavee—i.e. the rocks included in the divisions 1, 2 and 4 of Wynne.

15. The Punjab Government hydro-electric power plant at Mandi and its bearing on the mineral resources of the Mandi State.

S. K. Roy, Mandi.

By the construction of a dam across the Uhl, the leading of the water by means of a tunnel through the mountain, a fall of about 400 feet can be obtained at Sakrauti in Mandi State, a small feudatory State situated high in the Himalayas. The Punjab Government has taken this work in hand and is constructing a large hydro-electric power plant at this place.

Mandi State contains large deposits of salt and the author has also found important deposits of iron (a mixture of magnetite and hæmatite) manganese and dolomite. The petroliferous beds of Jawalamukhi have also been traced in Mandi.

The salt deposits contain in addition to NaCl, about 14% of K.Cl. With cheap electric power the preparation of sodium, and potassium chloride and their derivatives will be possible while other ways in which electric energy can be utilised in the development of the State are discussed. The iron ore could also be reduced by electrolytic hydrogen.

16. The age of the so-called Danian fauna from Tibet.

G. de P. Cotter, Calcutta.

17. The distribution of the Gault in India.

G. de P. Cotter, Calcutta.

18. On the discovery of an Indian species of Blanckenhorn's genus *Dictyoconus*.

L. M. Davies.

The author describes the discovery, near Hindu Bagh in Baluchistan, of the first species of the genus *Dictyoconus* to be found in India, which he accordingly proposes to call *D. Indicus*.

The form appears in great abundance in a small pocket of Eocene rocks (Lat. 30° 39½′ N.; Long. 27° 54½′ E.) near the Chrome Company's Mine No. 136. The horizon of these Eocene beds was defined as Ghazij Shale (probably Ypresian) by the late Mr. Vredenburg; and numerous specimens of *Ostrea, Natica, Gorbula, Mactra dubia* d'Archiac and Haime, *Cerithium chapari* Bayan, and *Dictyoconoides vredenburgi* Davies, are associated with *D. Indicus*. Both megalospheric and microspheric forms of indicus are found; the former being smaller and more steeply coned than the latter (usual dimensions being 3·5 mm. high by 3 mm. breadth of base for the megalospheric type, as compared with the same height but 6·5 mm. breadth of base for the microspheric generation). The internal characteristics of the two types, however, leave no doubt as to their specific identity.

Dictyoconus indicus is closely affiliated to *D. egyptiensis* Chapman, which is found in certain Eocene beds between Cairo and Suez. The purely calcareous test of the Indian form, however, and the more pronounced and spiral development of its primordial chambers (a primitive feature, approximating it to Stache's genus *Coscinolina*) entitle *indicus* to be considered a distinct, and perhaps slightly earlier, species. It is also rather smaller than *egyptiensis*.

Figures of the megalospheric form of the species have already been published by Major Davies (*Records, Geological Survey of India*, Vol. LIX, Part 2, Plate 20, figs. 13-13*b*) while describing the associated species *Dictyoconoides vredenburgi* ; and further illustrations accompany the present description of the form.

Section of Medical and Veterinary Research.

President:—Major R. N. Chopra, I.M.S.

Presidential Address.

Some Aspects of Therapeutics in India.

Ladies and Gentlemen,

I consider it my duty in the first instance to express my grateful appreciation of the great honour that you have done me in electing me to occupy the presidential chair. Not only do I look upon it as a personal honour, but to me it is an appreciation of the institution to which it is my privilege to belong, and which has on two previous occasions during the last five sessions of this Section supplied you with a Chairman. I shall endeavour to serve you to the best of my ability and in this I shall be guided and encouraged by the example of my distinguished predecessors in this chair, some of whom I am very glad to see here to-day.

Some aspects of the subject of drug therapy which I am going to bring to your notice, are important both from a professional and economic point of view. Medicine is an ancient art and drugs have been used as far back as history can take us. It is impossible to think of medicine as something not connected with treatment, and drugs have from the very beginning formed an integral part of treatment. Not only does a great deal of the success of medical treatment depend on the proper and correct use of drugs, but the success of surgery also has been largely dependent on the development of medicine. Surgery is, in many diseases, only a crude branch of therapy and its greatest achievements have rested on the discovery of such drugs as anaesthetics, antiseptics and disinfectants which play an all important part in this art.

Although the use of remedies dates back from antiquity it was only during the last half a century that a study of the action of drugs has been undertaken on scientific lines, and rational explanations are now forthcoming after a long period of empiricism. The development of organic chemistry, the systematic study of the relationship of chemical constitution to the physiological action of active principles, have been instrumental in producing a large number of new drugs, some of which have very potent actions on animal tissues. Scientific study means much experimentation, and success only comes after many heart-rending disappointments. The history of the science of materia medica shows many more failures than

successes. One has only to remember how many unsuccessful compounds Paul Ehrlich had to prepare and test before he discovered such effective compounds as salvarsan and neosalvarsan.

Irrational therapy on the part of practitioners.

The number of members of our profession in this country who make use of drugs in an irrational way is surprisingly large. In ancient times therapeutics was empirical because the aetiology and pathology of disease were not thoroughly understood, and our diagnostic methods were limited to our senses, e.g. percussion, auscultation, etc. During the last 30 years a remarkable advance has been made in these branches and drug therapy of today is likewise emerging from empiricism so as to be based on the clearer conceptions of physiology, aetiology, and pathogenesis. Unfortunately the non-critical and indiscriminate use of drugs is prevalent in spite of this advance in our knowledge. One has only to look at most of the prescriptions written by practitioners in India to see the true state of affairs. There is a great temptation to prescribe 'shot-gun' prescriptions, as well as to advise the use of all kinds of novelties, introduced from time to time and which survive for a year or two in the drug market. Proprietary medicines, the composition of which is not known, are commonly prescribed, and different kinds of patent foods are advised, when simpler remedies would be of equal value. Many kinds of digestive ferments and glandular products are included in prescriptions and they are frequently inactive, especially in India where their proteins are so readily liable to decomposition. Vaccines and serums are injected, without due regard to their utility in the conditions under treatment. Amongst the lay public there is a craze for the administration of drugs by the intravenous or intramuscular routes, and the idea seems to have gained ground among medical men that drugs are only effective when given in this manner. Then again any drug advertised in a medical journal is considered to be useful if it is backed by testimonials. It does not seem to be realised that in addition to a large number of useful and potent drugs on the market there must be a host of others of doubtful value. Every mail from Europe brings to the practitioner in this country a number of new drugs for which the chief evidence of efficiency depends upon their trial on a few cases of a particular disease treated mostly by individuals who are not trained investigators. The majority of these so-called remedies have a very short life but during this period they often enjoy a rich harvest of patronage. They are however useless, and practitioners frequently try them on many of their patients without doing the least good.

Too much drugging.—There is also a tendency among practitioners to overdose their patients with drugs, and an

enormous amount of money is wasted on medicines. Cases of such fevers as enteric and many other conditions for which no specific medicinal treatment exists are dosed with all sorts of complicated mixtures, when attention to diet and other forms of general treatment such as proper nursing and care of the sick and convalescent would do more good than all the drugs in the Pharmacopœia put together. The public in this country, more than anywhere else, have a child-like faith in medicines to cure all their ills, and judge the efficacy of a treatment from the number of medicines prescribed. Medical practitioners are often too complacent in satisfying this desire and sometimes even encourage it. When I have seen a patient and only prescribed general dietetic treatment and nursing I have often been asked "Is not the patient going to have any medicine?"

It will not be inopportune to consider and try to comprehend the causes of this irrationalism on the part of practitioners. For only in such wise may one plan to mitigate, if not altogether to eradicate the evil.

Medical Education in India.

The first and foremost cause of the present low status of medicine in India is the defective education in medicine generally and in pharmacology particularly, which is given to the student in this country. Two grades of medical practitioners are trained; a superior grade whose education comes to nearly the same standard as that of the students in England and America, and an inferior grade (sub-assistant surgeons), who have a shorter training. The pre-medical education of both these grades is very poor. Abraham Flexner in his book on medical education says that the medical student both in America and England is poorly educated. This applies with even greater force to the student in India. In the one or two years preceding medical studies, too much attention is paid to the scientific subjects, with the result that general education in subjects such as logic, sociology, psychology, history, economics, english literature, and rhetoric is neglected. The majority of the medical students in consequence are lacking in the broad outlook given by general education and the knowledge of the forces governing human interests and behaviour. Instruction in other languages such as German and French in which a large amount of scientific literature exists is not given in most colleges.

There are eight medical colleges in India turning out on an average 800 medical practitioners every year, but there are also a large number of medical schools which train many thousands of practitioners. The education of this latter class is of a lower standard and does not entitle them to re-

gistration in the United Kingdom. This kind of education is on the increase, owing to the economic conditions prevailing in the country, but the demand is incessant and so a further number of schools are being opened everywhere by private and public enterprise. In Bengal an attempt is being made and proposals have already been put forward to have a medical school in each district. A few of the institutions in the central provincial towns are well equipped and well conducted, but most of them are poorly equipped, badly staffed, and entirely unsuited to train a good class of practitioner. The result is that many of the general practitioners in India have a poor medical training. Even in the medical colleges, though the education is of a higher order, it is not entirely satisfactory. The system of imparting education is faulty. The method of selection of teachers and professors is such that most of these coveted appointments often do not go to the best available men. The provincialisation of the medical services has only made this state of affairs much worse, so far as the service men are concerned. In the old days the choice could be made from the services all over India for a chair in a particular subject, whereas now the selection is confined to a small cadre serving in the particular province in which the institution is situated. Further, there is little or no leave reserve for these particular appointments, and when an incumbent proceeds on leave the nearest available man is put in to officiate irrespective of his qualifications. The result is that at one time a teacher may be giving instruction in anatomy, at another he may find himself professor of pathology and bacteriology, and shortly after he may be installed perhaps as ophthalmologist, to be followed by his officiating in a chair of gynæcology and obstetrics. In this way it is not unusual to find a class of 'universal professors' and the instruction of the students suffers for obvious reasons.

Medical Curriculum.—Secondly, the medical curriculum in this country both in the schools and the colleges is far from being satisfactory. In countries like England and America and many European countries the curriculum has been recently overhauled and many reforms have been introduced to make it as practical as possible. The General Medical Council have carefully considered the question and Sir George Newman in his memorandum has examined every aspect of this important problem and has suggested useful improvements. The medical curriculum of to-day in India is wasteful in its method of teaching and is full of detail of all sorts representing "the conceptions of half a century ago with certain laboratory procedures superimposed." The course is overcrowded and an attempt is often made to impart to the students a lot of antiquated knowledge from text-books to the detriment of the general principles of the subject so that he only gets a

very superficial knowledge. Great importance is attached to lectures and the student spends a great part of his time listening to them. Lectures based on actual experience are worth hearing, while others read from text books can be more easily read by the student himself. Swale Vincent said that lectures are survivals from days when there were no text books. But in India there is a scarcity of suitable text-books. In fact many of the lecturers in this country use unsuitable text-books for their lectures, which does not enhance the value of their teaching. Others give intricate dissertations, whereas they ought to present clearly and concisely the subject in hand, keeping in mind the level of the student's intelligence, many of whom can absorb only a little at a time. The great mass of theory and knowledge should be presented to the students in a carefully prepared systematic and concise form so as to enable them to grasp the essential facts and understand how to utilise the details.

Practical instruction also needs a great deal of improvement. A lot of unimportant detail is taught which is of no use to the general practitioner. Improvement in the method of instruction will result in the students learning more in a shorter time. This can only be attained by industrious work and devotion of a lot of time on the part of the instructor, and it must be done if the students are to be instructed properly. Unfortunately under the present system of medical instruction in this country it does not appear to be possible. Most of the teachers in the colleges are engaged in private practice to which they devote most of their time, and consequently the majority of them cannot give sufficient time to the proper teaching of their subject. In America whole-time professors are often employed and this is also the case with countries like Germany. In England the advantages of this system have only recently been appreciated and it has been introduced in some medical schools. The advantage of this system is that professors and teachers have not to earn a part or the whole of their livelihood by seeing patients. They are therefore free from the anxieties of practice and can devote themselves entirely to their subject and come into closer contact with their students. In India at present, the teachers and the students live in two entirely different worlds. The teachers have not the time to know their students, and further, owing to the large numbers that they have to teach in their classes, it is impossible for them to come into personal contact with any but the most brilliant. Furthermore if the lecturers had more time at their disposal they could devote themselves to scientific research in their subject. The great progress made in scientific medicine in countries like America and Germany is mainly due to this scheme, and if it could be instituted in all the teaching institutions in this country the stigma that India's contribution to medical research is small would soon be removed.

The teachers should be well qualified and should be given a living wage suited to their position. The idea that good men will not be forthcoming to take up these appointments under such conditions is not correct. There are many excellent men who prefer a life of study and scientific research to a life of gain, and who would be admirably suited for the posts of professors and teachers. In suggesting the introduction of whole-time professors I am fully conscious of the disadvantages of this system. Many diseases and symptoms met with in private practice are hardly ever seen in hospital practice. It has also been pointed out that the teachers learn the needs of the general practitioner as regards extension of his knowledge, etc. by being in touch with that class of practice. This object could, however, be attained by throwing open some of the clinical appointments to distinguished practitioners or by restricting the private practice to limited consultant practice in case of a few of the senior members of the hospital staff.

Pharmacology.—Thirdly, Pharmacology, the science of the action of drugs, has practically no place either in the curriculum of the medical schools or of the colleges in this country. We still carry on with old fashioned "Materia Medica" in the true sense of the word. The General Medical Council of Great Britain has laid stress on the proper teaching of this subject, and yet in very few of the medical schools and colleges in India are there proper arrangements for giving practical demonstration and instruction to the students in practical pharmacology. The little instruction that is given on the theoretical side is imparted during the second and third years when the student's mind is not properly ready with the basic facts of anatomy and physiology. He is taught the therapeutic use of drugs when he does not know even the names of the diseases, much less their symptomatology, aetiology, and pathogenesis. The action of drugs on tissues, which forms the foundation of treatment of disease, is considered so unimportant that any medical man without any technical knowledge is considered proficient to teach it. The importance of proper teaching of this subject cannot be over-rated. Professor W. E. Dixon, a few years ago said, "To state that the future of medicine lies in pharmacology may sound fanciful, but it is certain that the most hopeful of all signs of progress of medicine of to-day is to be found in the progress of the science of treatment." Though diagnosis is of prime importance, the patient is less interested in it than in the treatment of his disease, and pharmacology forms the basis of treatment. It tries to localize the seat of action of drugs, the mechanism of their action, and gives information about the nature of physiologic and pathologic processes. It deals with the changes produced by chemicals and physio-chemical agents, not only in healthy tissues but also in diseased ones. It is not merely a question of transferring results

from isolated pieces of intestine or the uterus of animals to human beings, as is imagined by some. Circumscribed syndromes can be produced in experimental animals and the effect of therapeutic measures can be tried on them. In this way new drugs and chemicals can be thoroughly tested, not only in healthy animals but also in those in which special diseases have been induced, before they are tried on human beings. Laboratory pharmacology is the basis of research into practical therapeutics. It is responsible for the introduction of many useful compounds of arsenic, antimony, and bismuth into therapeutics. It is clearing away antiquated methods and remedies and is purifying those that remain. A sound training in pharmacology alone can make drug therapy more rational. The teaching of pharmacology in India should be improved and remodelled and the sooner it is done the better. Only by this method is it possible to exclude the empiricism that surrounds our art. The irrational tendencies among medical practitioners are bound to go on until the teaching of pharmacology is put on a sound basis in this country. Trained pharmacologists, however, in the Indian teaching institutions are at present mainly limited to the Calcutta School of Tropical Medicine, but we are training experimental pharmacologists for various provincial governments.

The teaching of Tropical Medicine.—Lastly, the student is given inadequate instruction in the treatment of the diseases peculiar to the tropical and subtropical climates of this country. It is admitted that strictly speaking there are remarkably few tropical diseases. Most of the great scourges met with in the tropics, occur in temperate climates also, and many of the dangerous diseases of temperate climates are met with in the tropics in altered forms. A study of the effects of climate, tropical sanitation and hygiene, has however a very important bearing on the understanding of disease, as met with in this country. These diseases are totally different from those described in european text-books. It is important therefore to emphasize tropical medicine in the curriculum of our colleges, and arrangements should be made for instruction in this subject to be fitted into our undergraduate course of studies.

Advertisement and New Drugs.

The second factor responsible for irrational drug therapy is the publicity which is given to drugs through notices in the medical and the lay press and by means of circulars broadcasted to the members of the profession. There are many manufacturing drug houses in Europe and America which prepare a large number of products and introduce them to the profession. They make sweeping claims regarding their therapeutic value, without producing very satisfactory evidence in support of their contentions. Some of these advertisements do

considerable harm and they even persuade people that in order to keep well they must constantly dose themselves with the drug. They certainly encourage long distance diagnosis and treatment, and lead to the postponement of the application of proper treatment, sometimes with very bad results. The loss of time resulting from the use of ineffectual symptomatic remedies is a serious matter and there is also a great danger of drug addiction.

Professor Clark in a paper entitled 'Commercial Influences in Therapeutics' very ably and forcibly brought these facts to the notice of the profession in England. He said that in that country—and the same law applies to India—there were no safeguards in the claims made for patent and proprietary medicines in advertisements which were demonstrably false. For all practical purposes the British law is powerless to prevent any person from procuring any drug or making a mixture whether potent or without any therapeutic activity whatever, so long as it does not contain a scheduled poison. He can advertise it in any terms as a cure for any disease or ailment, and recommend it by bogus testimonials under facsimile signatures of fictitious physicians, and sell it under any name he chooses on the payment of a small stamp duty, for whatever price he can persuade the public to pay for it. The therapeutic promoters occupy a position of great power. They control the lay press on account of their advertising capacity, and through it Parliament; they exercise a considerable influence over the medical press also.

In America the legislation for controlling proprietary and other drugs is very effective and the provisions of the 'Food and Drugs Act' are very comprehensive. This law lays down that in case of proprietary medicines labels or packages should not contain any statements of therapeutic or curative effects of drugs which are false or fraudulent. The use of the word 'cure or remedy' should be used only for those medicines which are 'cures or remedies' for the conditions named on the label. The placing on the label of the names of diseases is taken to imply that the medicine contained in the package is in itself a treatment for the diseases or the conditions named. This has led to the exclusion of these terms and the substitution of such expressions as 'will often relieve' or 'will aid Nature to restore,' etc. People who use these remedies on the strength of no stronger evidence than these weak assertions only have themselves to blame for the results. It is surprising, however, that even these vague and non-committal advertisements in the medical journals succeed in impressing the medical man. One reason is that on account of his genuine modesty the medical practitioner is prone to receive with undue respect any kind of plausible nonsense which appears to be scientific, and the therapeutic speculators who introduce new drugs get at the medi-

cal profession in this way. This is especially the case with biological products, which are now much in vogue. The field here is new, the mode of action of these substances is not thoroughly undertsood, and few general practitioners are well informed concerning them. Besides this, remarkable results sometimes follow their use which impress physicians and encourage their indiscriminate use in all sorts of conditions.

In America, the Council of Pharmacy of the American Medical Association is serving a very useful purpose in bringing before the profession the truth concerning new proprietary preparations. This Council consists of reputed clinicians, pharmacologists, and chemists, and has a well equipped chemical laboratory. It investigates all the new preparations put on the market and carries on a propaganda for the rational use of drugs. Those remedies which give promise of being more or less of value in the practice of medicine are put into its annual publication called the 'New and Non-official Remedies' or as it is briefly called 'N.N.R.' Those which are not approved by the council are dishonest or worthless preparations. Those remedies which are included in the N.N.R. to begin with and which are subsequently found to be useless are excluded from later editions.

New Drugs and Old.

Most new drugs are introduced into medical practice either through the agency of scientific investigation or through commerce. When they come through science, exaggerated claims as a rule are not made regarding their therapeutic value. When they come through commerce, financial considerations unfortunately often dominate the situation and exaggerated claims are not infrequently made to create a demand for them among the medical profession. The advertisements are often couched in scientific or pseudo-scientific language to impress practitioners. Commercial advertising for this reason is often misleading, though it must be admitted that many of the good class drug houses employ men with high scientific attainments, and advertise and place only such products on the market as have been properly tested. A really good drug wants no advertisement. In a very short time the most laggard of practitioners will start using it, not only for the disease in which it is efficacious but also in many other conditions in the hope that it may do good. Emetine is not only used as a cure for amoebic dysentery but is also used in the bacillary form and in many other conditions. The organic arsenicals and organic compounds of antimony are being tried in all kinds of diseases. A great many novelties however are being brought out which are not sufficiently tried. This tendency of modern medicine towards too readily accepting new remedies is to be greatly deplored. As soon as a new remedy is put on the

market, practitioners hasten to prescribe it. They feel no reluctance to try new things, even though their minds are not properly acquainted with the use of old and well tried remedies whose actions are established and which are known to be of value in the treatment of diseases. They do not realize that new drugs and new methods of treatment require a long and serious study by able and experienced investigators before their beneficial effects can be established and their harmful effects discovered by treating many cases, before they can be introduced into therapeutics. The disadvantage of using new remedies is that the confidence in the old and beneficial remedies is lost. New drugs should never be allowed to come into use unless they are of unquestionable value. In the public interest they should go through proper preliminary experimentation, with adequate controls. Sir William Osler talking about the danger of new drugs and about falling under the claims of pseudo science and commercialised empiricism, said "Give our students a first hand acquaintance with disease and give them a thorough practical knowledge of the great drugs, and we will send out independent clear headed cautious practitioners who will do their own thinking and be no longer at the mercy of meretricious literature, which has sapped our independence." It is because of his faulty training that the practitioner makes use of these old-established drugs in a perfunctory manner. Not understanding fully the action of well known and recognized remedies, and not knowing how to combine them for the treatment of disease, he takes the easiest way out and prescribes ready-made products whose action and indications for use are all made available to him by drug circulars. Proper instruction of the student is the most effective weapon against the evil of falling into the hands of therapeutic speculators. The intelligent selection and proper administration of therapeutic remedies depend essentially upon skilled teaching. Drugs should be given with an object, and it is the duty of the physician to verify at each stage whether this object is gained or not. If treatment is conducted in the same way as scientific investigation, irrationalism will disappear from our therapy.

Control of Therapeutic Agents in the Market.

It frequently happens that a practitioner seeks the new drugs because he has lost confidence in the old ones. This is due to the fact that a large number of drugs which appear for sale on the market in this country have not always the therapeutic activity which they are alleged to have. The factor of climate is of great importance; the high atmospheric temperature combined with a high degree of humidity produce deterioration of drugs during storage. For the last few years I have been engaged in examining by chemical and biological assay many

preparations of potent drugs on the market, both those manufactured by the drug houses in India, and those imported into India.

(1) Those manufactured in this country are subjected to no control whatever by the State to see that the quality of the preparations is up to the standard laid down in the pharmacopœia. I have tested a number of such preparations and have found them to vary a great deal in their strength. In some cases the preparation came up to the prescribed standard, but very often they were below the average, and sometimes quite inert and therefore useless for therapeutic purposes. This is specially the case with preparations made from such drugs as digitalis, strophanthus, squills, ergot, cannabis indica, etc. These preparations, which can only be assayed by biological methods are put on the market without their potency ever having been tested.

There is no law to prevent this. There is, so far as I know, only one firm of manufacturing chemists in India who get their products biologically assayed before putting them on the market. The shortcomings of biological assay are admitted, and we know that it is only accurate within 20 per cent. and the margin of error is wide. But from the point of view of the practitioner some form of standardization is necessary for all potent drugs, and more particularly for those drugs of which the active principles cannot be isolated, because it is especially in these that there is danger of obtaining inactive products. Not only are galenicals and other pharmacopœal preparations manufactured by Indian firms, but attempts are being made to prepare some of the biological products such as gland extracts, vaccines and serums, and some of these have been put on the market. Besides these, a number of potent organic compounds of antimony have been introduced by some manufacturing firms in Calcutta and are being largely given intravenously by practitioners. No control whatever is exercised by the State over these potent compounds with a view to see that different batches of these manufactured products are chemically the same and that their toxicity has not varied. In case of all organic arsenical and antimonial preparations introduced into therapeutics in America and the European countries a strict and severe test is enforced.

(2) With regard to the imported drugs, which form by far the largest proportion of drugs used in India, most of them are manufactured by reputed firms who employ a competent staff of chemists and pharmacologists to standardise them. The climatic conditions however in this country have to be taken into consideration. A few years ago my laboratory tested nearly a hundred preparations of digitalis made by reputed firms and found that most of these had deteriorated to the extent of 30 to 40 per cent within a few months of their arrival in India.

Some drugs such as thyroid extract, adrenalin, pituitrin, etc., are similarly affected. Several batches of old tablets of pituitrin and adrenalin and some containing potent alkaloids which we tested had appreciably deteriorated in quality. The keeping properties of organic arsenicals and a number of other potent remedies when exposed to tropical climates, still remain to be worked out. Control of these products on the market is therefore of prime importance.

Therapeutic Substances Act for India.

In the United States of America the Government controls the remedial agents by means of an inter-state commerce clause of the constitution. Under this act the "Food and Drugs Act" is enforced by the Bureau of Chemistry of the Department of Agriculture, while the sale of biological products such as serums, vaccines, etc. is controlled by the Public Health Service. Not only is control exercised over all drugs, serums, etc., that are meant for home consumption, but all substances belonging to this class which are imported or exported are also governed by the Act. The Act is designed to secure truthful names and reliable statements for all the remedial agents and is divided into two parts.

Part I of the Act is concerned principally with preparations primarily designed for the use of the laity direct, and Part II applies to medicines ordinarily prescribed by physicians. This Act ensures that the purchaser, whether a physician or a layman, secures an honest product. It means that pharmacopœal preparations must come up to the standards laid down in the *United States Pharmacopœia*, failing which the manufacturers will be prosecuted. In the case of patent medicines the law requires that only those claims should be made which can be substantiated, and in this way it controls the exaggerated claims and misleading and false advertisements. Standards are provided for most of the biological products. In the case of preparations for which tests of standards are incomplete, the samples are sent to the Government Laboratory with a copy of the record of the maker's tests and these are repeated and the preparations are finally passed for sale or rejected. The toxicity of each batch of organic arsenical products is tested before it is allowed to be sold. No license is granted to any firm until the licensing authority is satisfied that the personnel and equipment of the firm is qualitatively and quantitatively efficient for the purpose for which the license is sought. In addition to this licensing system, samples of finished products are bought in the open market and are tested by officers of the Government with regard to their purity and potency. By these activities a constant control is kept over these drugs, and the postal authorities are responsible for the prevention of

frauds and exploitation through the post. In England the 'Therapeutic Substances Act'—corresponding to the American 'Food and Drugs Act'—was introduced only recently, but its terms are not so comprehensive. This Act controls the quality and authenticity of such therapeutic substances as cannot be tested adequately by direct chemical methods. These are divided into three groups. *Group I* consists of biological products, such as vaccines, toxins, and antiserums. *Group II* includes substances such as organic arsenicals and antimonials. *Group III* is formed of insulin and other gland products. The manufacture of these substances is carried out by properly licensed firms who conform to the standard of strength and purity laid down by an appointed committee.

In India there are no safe-guards whatsoever against manufacturing, advertising, and selling to the public therapeutic products of any kind, whether potent or inert, effective or ineffective. The result is that a large number of medicines, both proprietary and otherwise, which are presented for sale in the market, fall far below the standard. Lately a good deal of interest has been taken in this subject and in a lecture to the Rotary Club at Calcutta the subject was brought up for discussion. The speaker suggested that measures on the lines of the British Food and Drugs Act—I presume that he meant the 'Therapeutic Substances Act'—should be passed in India as a means of protection against the indigenous production of patent and other medicines. At present, while in other countries regulations regarding the preparation and sale of medicines are very strict, no standard whatever of any kind is imposed in India. Many manufacturers in this country produce articles which have only a slight resemblance to the standard or genuine articles, and therefore firms anxious to produce only reputable goods cannot compete with them. The excise authorities instituted an enquiry into the causes of falling off of sale of rectified spirits, and found that in many cases alcohol was not being used in the quantities necessary to produce the standard articles. The medicinal or therapeutic value of the preparations may be negligible and the consumer has no guarantee that the standard of activity is being maintained. Large quantities of medicines are sold in tablet form, offering an excellent opportunity for deception, and an example was given wherein 5 grain tablets of quinine consisted of only one grain of quinine and four grain of starch or other inert matter. Essential oils such as sandal wood oil, cinnamon oil, etc., and preparations such as vinum ipecacuanhæ have many inferior substitutes on the market.

Such being the case, is it at all surprising that the profession should lose confidence in these remedies? And it is this want of confidence which leads the physician to try anything new that reaches him by means of advertisement and drug circu-

lars. The question of protection from these medicinal frauds touches not only the physicians but the whole of the public, and an act on the lines of the British Act, or better still on the lines of the American Act, is the only possible remedy.

Control of Dangerous and Narcotic Drugs.

In many civilised countries dangerous drugs, including narcotic drugs, are controlled by the State. In Great Britain recently as the result of an enquiry by a Committee, regulations concerning the manufacture, sale, and even professional use of narcotic drugs have been extended and re-enforced, and many drugs such as barbituric acid derivatives like veronal have been included in the schedule. Addiction to such drugs as morphine and heroin, according to this committee, are rare in England now owing to enforcement of the Dangerous Drugs Act which makes it very difficult for the addicts to get these drugs except through a medical practitioner. In India there is little or no control over the sale of these drugs. Though drugs like morphine and cocaine are not supplied except by a prescription from a physician, opium and cannabis indica are sold to any one who goes to the shops licensed by the State, and addiction to these drugs has increased during the last decade. Large quantities of cocaine are also smuggled into the country and this most vicious of all drug habits is prevalent among a certain class of the population in India. Recently some interest has been taken in the problem of the opium habit, by public bodies such as the Indian National Congress and the Government has been urged to control the production and sale of opium. The sale of all narcotic drugs needs to be brought under more strict control. In countries like America drug addicts are registered and are regarded as willfully vicious individuals; they are notified to the authorities before drugs can be supplied to them. Legislation on similar lines which would not only make it very difficult for the general public to buy these drugs but would also brand the addict with a stigma is the only means to prevent the spread of drug habits.

Need for Central Organisation. Therapeutic Research.

The control of therapeutic remedies on the market can be properly effected only if there is a central organisation, similar to that existing in the United States or like the Medical Research Council in England. Things are so complicated and specialised now-a-days that the investigation of details is beyond the power of any one individual. The chemists, the pharmacologists, the physiologists, and the biochemists must work in co-operation with each other and should have all the facilities necessary for their work. This can only be effectually done if there is a

central organisation under the control of the State, capable of testing substances from every point of view. This central organisation will not only help in the control of the therapeutic agents on the market, but having competent men representing all branches of medicine on its staff, it will conduct therapeutic and other researches on the important problems which are peculiar to India. It should be situated in a large centre where ample clinical material is available. The central organisation could have ramifications spread all over the country, so that problems peculiar to different parts of the country could be dealt with efficiently. Our problems are numerous, immense, and unworked, aud if such an organisation comes into existence a tremendous impetus would be given to medical research in this country. It is about time that a beginning on some such lines was made. Until quite recently the idea of medical research in this country was mainly confined to bacteriology and to the closely allied branches of medicine; in fact the Medical Research Department under the Government of India was known by the name of the Bacteriological Department, and most of the appointments under it even now are filled by bacteriologists, protozoologists, and entomologists. Research should be looked upon from a much broader point of view. We should have research workers in all branches of medicine in order to examine every aspect of our medical problems. The importance of medical research does not appear to be sufficiently appreciated by the public in India. It is not realised that the foundations of medicine and its application are based on research, and that the protection and advancement of research is the primary duty of the State. Sir Ronald Ross in a lecture recently said that to human beings medical discovery was the most important of all kinds of discovery and the amount of public attention given to it was disproportionately small. He said that in England the total amount provided for medical research worked out to about one penny per head of population per year, and tremendous results were expected by the public for this small expenditure. The contribution of the State towards medical research in India is very small indeed considering its size and its population. Medical Research has suffered for want of means. It requires expensive laboratories, costly apparatus, and a staff of competent workers who have to be well paid, but the statesmen who are responsible for the public purse somehow seem to be reluctant to spend money on it. The short-sightedness of this policy has at last been realised in England. During the last few years, the United Kingdom has been spending £140,000 a year on medical research, and the immense value of the work done and the benefits which the public have received from it are now being appreciated. The future of medicine in India depends on ample provision being made for the vigorous prosecution of research. Its benefits will soon be

appreciated. State recognition of research will also stimulate voluntary endowment. On this also depends the improvement of medical education and the turning out of a good type of practitioner. The spirit of research should be inculcated in all the teaching institutions, as there is no doubt that the best teaching can only be carried out in an atmosphere of research, and the best students can be turned out by men engaged in research work. Research and teaching are intimately connected.

The advantages of such an organisation would be very great indeed and the resulting economic gain to the country would be enormous. There is a large number of problems which challenge the medical research worker and which might be worked out to the great advantage of the people. The standardization of treatment with such remedies as quinine, emetine, antimony, and arsenic compounds, etc., for diseases prevalent here will not only be of importance from a medical but also from the economic point of view. If maximum and minimum effective doses of such drugs, and maximum and minimum periods of their administration are worked out by a properly constituted body of experts a lot of waste could be avoided in the use of these drugs. The saving effected would more than pay for the cost of upkeep of such an institution. Even for such a prevalent disease as malaria no standard treatment has so far been worked out, and the amount of the expensive cinchona alkaloids which are wasted on account of the great disparity of doses is enormous. Major Sinton's work in this connection is most valuable, but being single-handed he can only investigate one aspect of the problem at a time. Here is a field of medical research where co-operation might considerably facilitate a most useful inquiry. The State alone could give facilities for work with an ideal population under control such as the army, and non-infective sites such as hill stations where experiments could be properly conducted. I do not wish to go into details of the many important problems peculiar to India which remain unsolved, but I think that it may not be out of place to mention some of them to show their importance.

Filariasis is prevalent, not only along the sea coast but some hundreds of miles inland. Although a complete survey has not been made for the whole of India, the work done at the Calcutta School of Tropical Medicine shows that in eight districts in Bengal the population is affected to the extent of 4 to 16 per cent.; in Behar, Orissa, and Chota Nagpur the figures are much higher, going up to 27 per cent. Most of the sea coast districts of Madras and Malabar are heavily infected. A large portion of the population of these areas is incapacitated from this disease every year. Yet a perusal of the literature on the subject shows that very little work has been systematically undertaken to find out an effective treatment for this

disease. Another allied disease which is also responsible for a lot of incapacity in Central India and Rajputana is *dracontiasis* or guinea-worm infection. We are still where we were half a century ago regarding its treatment, and with the exception of the work done by Dr. Hamilton Fairley the problem has not been worked out. A disease of great importance is *kala-azar*, which has and is still taking a very heavy toll from the inhabitants of Assam and Bengal. This is one of the few Indian diseases on which systematic work has been undertaken, and it affords an example of what can be done by properly conducted research work. During the last decade the mortality rate of 90 per cent. caused by this disease has been changed into a cure rate of 90 per cent. by the development of its treatment with pentavalent compounds of antimony. Many questions, however, in connection with its transmission, prevention, etc., still remain unsolved.

Ringworm is one of the most widely prevalent of skin diseases in all parts of India and it is responsible for a lot of incapacity. Major Acton, during the past year, has been engaged in the differentiation of its species and the recognition of the pathological lesions produced in man by this disease, but with this exception no attention has been paid to this important source of incapacity. A pest which regularly visits Bengal every year about the end of the rainy season and of which we have had a big outbreak last year is epidemic dropsy. It is responsible for much incapacity and has a fairly high rate of mortality, but we are still not quite clear about its aetiology, pathogenesis, and treatment, though the investigations made in connection with it at the Calcutta School of Tropical Medicine during the last few years have thrown a good deal of light on it. A group of conditions including infective conjunctivitis, infective granulomata, and tropical ulcers, though not serious to life are responsible for much disability and do considerable harm to the population; they form a practically unexplored field. Pernicious anæmia of pregnancy, osteo-malacia, and infantile cirrhosis are common in some of the large towns of India. Dengue and a number of fevers of short duration are prevalent, but their ætiology is not solved. The post-dysenteric conditions such as asthenic diarrhoea, chronic peritonitis, and cirrhosis of the liver are prevalent but we have little knowledge concerning their pathogenesis or treatment. Tuberculosis is spreading in many parts of India and so far nothing has been done to find out the reason for this increase and the measures which can be taken to prevent it. Drug addiction has also increased since the war.

Training of Research Workers.

Such are some of the problems peculiar to our couutry that can be tackled by experts at a central institution in the areas

affected by the diseases concerned. Such a body alone could make concentrated efforts and attack them from every point of view. Considering the immensity and importance of these problems to the welfare of the people, it is obvious that the State would be quite justified in spending money to give facilities for their investigation. The first great need is for a fully staffed and thorough equipped central institution in which workers can be trained and from which investigators can be sent out to investigate diseases in the places where they occur. In addition to this the local governments should be encouraged to provide research laboratories for work on the special diseases of each province. Medical research to-day is not a single man show; at every stage one needs the valuable assistance of colleagues of real worth. Without their co-operation, progress is bound to be small. Unfortunately we have at present very few such trained workers available in India, either in the services or outside, for the simple reason that there is no proper training ground for them. There are a number of enthusiastic young men educated in the Indian as well as the British and American universities who take a keen interest in this kind of work, but they cannot take it up for lack of opportunities. It is essential that provision be made for the training of young workers and for ensuring a prospect of a decent livelihood for them in research. The result of the present state of affairs is that when a new line of research is to be started there is very great difficulty in finding suitable men for it and a worker from outside has to be imported on a very high salary. As often as not funds do not permit of this, and the work is dropped entirely. The central institution could serve as a training ground for research workers. One of the duties of the experts on its staff should be to train suitable young men for research in different branches of medicine so that they would be available for work on different problems.

Medical, Veterinary, and Allied Sciences.

And last but not the least, I would like to bring to your notice the necessity for closer co-operation with the sister science of veterinary medicine and with such allied sciences as zoology and botany. The problems of the veterinarians are much the same as ours, and zoologists and botanists can render us considerable help in connection with the transmission and spread of disease and its pathogenesis. For nearly thirty five years Clifford Allbut advocated the importance of the study of comparative medicine. His ambition was to found a school of research in animal and plant pathology in Cambridge. A Chair of animal pathology was established a few years ago, and the beginning of a great school of comparative medicine and pathology has already been made in

that university. The tendency of the medical and veterinary professions to work in water-tight compartments is to be greatly deplored. Co-operation between the two professions can be of immense use in working out some of the obscure problems with which we are confronted in India. A section of comparative medicine was started a couple of years ago in connection the Royal Society of Medicine, and Mr. Frederic Hobday in his presidential address said "The foundation of our present position in the administration of anaesthetics, the splendid safety of our present day surgery, the study of therapeutics and pathology, even medicine itself, all had the principal part of their pioneer work done upon animal patients, before being applied to the human being." Those engaged in research work can fully appreciate the significance of the remark. In our every day experimental work on animals many points arise in which veterinarians could help us with their knowledge of animal anatomy, physiology, pathology, etc., to correctly interpret our observations and apply them to the service of man. Medical men and veterinarians are alike intimately concerned in pathogenic bacteria and protozoa, and there are many diseases in this country common to both men and animals. Rabies, Malta fever, anthrax, intestinal parasites, rinderpest, bovine tuberculosis, etc., and many skin diseases are transmissible from animals to man. A combined investigation of such problems would be of very great value to both and would not only help to alleviate the suffering of humanity but would also benefit the animal wealth and agricultural resources of this country.

I may urge in conclusion that my plea for a central research institution does not proceed from any class or service motives. I regard research in medicine as of prime importance, and for such research to be effective co-ordination and co-operation is essential. Such a growth can not be achieved by private or individual effort; the collective resources of the nation must pull together to attain the desired harmony and progress. I have pleaded for State help, for I consider that in a vast country like ours, where perhaps socialised institutions are the only effective agencies, a problem of such magnitude and importance can not otherwise be solved. A State exists for the good of the people, and what greater service is there than a growth in the health and vigour of the races concerned ?

Abstracts of Papers.

1. Evolution of a strain of vaccinia virus from the virus of contagious Epithelioma of fowls.

C. G. Pandit, Guindy.

Contagious epithelioma of fowls, or bird pox, in spite of its name, has been regarded by veterinary pathologists as distinct from the other animal variolas. Recent work of Zwick and Toyoda, tends to show, however, that it can be included in the group of viruses comprising the variolic family. Experiments are undertaken to study the relationship of the bird-pox virus with the viruses of variola and vaccinia. Attempts were first made by suitable passages on calves and monkeys to cultivate the virus into vaccinia virus. The work done so far may be summarised as follows :—

1. The virus of contagious epithelioma of fowls, when passed in succession on calves and monkeys, can be cultivated ultimately into vaccinia virus.

2. With calf passages alone such development was not effected. The interposition of a monkey was necessary.

3. The monkeys were not always susceptible to direct inoculation of the virus.—Out of 4 attempts, only one yielded a successful vesiculation. This was not however typical of vaccinia virus, and the monkey was successfully vaccinated with calf lymph fifteen days later.

4. The virus reacted negatively on both the skin and cornea of rabbits. When they were vaccinated with passage material obtained from different stages of development, the reaction first appeared only on the cornea. Only at a late stage of development towards vaccinia virus, did the material react successfully on both the skin and cornea.

2. Classification of Lactose-fermenters by serological methods.

T. Seethapathy Iyer, Guindy.

The pollution of water and food supplies responsible for dissemination of cholera, dysentery etc., is chiefly derived from intestinal contents. Any specific test that would enable human *B. coli* to be differentiated from non-human strains, will constitute a definite advance and assist materially in a rational assessment of the sanitary quality of water and food supplies. A serological test, based on observations on 650 human faecal strains and 599 cow-dung strains of lactose fermenters is described. In the practical application of this classification, some samples of water showing lactose fermenters in 60 c.c. passed as potable on existing standards have to be condemned on serological basis, if the lactose fermenters are human strains; while samples showing lactose fermenters in 1 and 5 c.c. volumes, stand to be passed as potable if the lactose fermenters are of the Bovine type.

3. A short note on three different varieties of fungous growths isolated from cases of Mycetoma that were admitted for treatment in the Madras General Hospital.

T. Seethapathy Iyer, Guindy.

4. A short note on a Yeast-like growth isolated from a case of Rhinosporidium.

T. Seethapathy Iyer, Guindy.

5. Some observations on the treatment of climatic bubo by Protein Shock.

G. H. Dive, *and* P. N. Basu, Madras.

All the cases presented the characteristic features, protracted course, irregular fever, unilateral enlargement with periadenites in the groin and marked increase in the size of the deep lymphatic glands. In one case suppuration had taken place in a previous attack in the other groin and in another case redness and softening were present in a limited area.

The clinical course of individual cases, the summary of intravenous injection with nature of protein, date, dosage, and comparative reaction as indicated by the blood changes, and the rise in agglutination power are all separately given. It can confidently be stated that considerable local improvement may be anticipated and possibly suppuration prevented by the adoption of this method of treatment. Fever was controlled in all cases. As regards cure, by which is meant the sterilisation of a supposedly underlying infection, this seems doubtful. Probably the injection of proteins acts merely by removing inflammatory products leaving the cure to the normal lapse of time.

6. Some observations on cases of anaemia and sprue in Bombay.

P. N. Basu, Madras.

The present studies deal mainly with the investigation into the cases of varieties of anaemia and sprue prevalent in Bombay. The enquiry had to be closed up without coming to a definite conclusion. Several methods were employed to find out their causes and the following facts have so far been elicited: There is a marked deficiency of free HCl on gastric analysis in all cases—it may be noted that the standard for Indians is much lower than that of Europeans. The estimation of neutral fat and free fatty acids in faeces showed a different ratio than that hitherto described. The average of 40 healthy individuals (Indians) showed a ratio of 1 : 2. 9. and in all diseased condition there is disturbance of this ratio, and in one case it was as high as 1 : 8. 8. In almost all the cases there is an increase of free fatty acid. The excretion of total fat was not high—thus differing from sprue where fats form more than 40% of the total weight of the dried faeces. None of the anaemia cases showed marked regenerative type of red blood corpuscle. Van de Bergh's test gave a positive indirect reaction with slight increase of bilirubin content in comparison with that of healthy individuals. The diastatic power of urine was normal—thus excluding pancreatic disease. Fragility test did not show diminished resistance of the red blood corpuscles. Calcium content of blood is found lower in healthy Indians in comparison with Europeans and there was not much diminution in diseased cases. Bacteriological examination of stools revealed the presence of a large number of putrefactive and fermentative organisms and the injection of some of them to laboratory animals showed that they are virulent in nature. Some of the cases improved after administration of autogenous vaccine prepared from a mixture of several intestinal organisms. No improvement was noticed in suspected sprue cases by the administration of calcium and parathyroid extract. There was slight diminution of blood lipoids in almost all the cases, showing deficiency of absorption of fats.

7. Tumours caused by intraperitoneal inoculation of *B. lepra murium.*

E. Muir, J. M. Henderson, *and* E. Landeman, Calcutta.

(1) The reasons which induced us to take up the study of rat leprosy are as follows:—

(*a*) The very close association between this disease and human leprosy.

(*b*) Human leprosy cannot be conveyed to lower animals, whereas almost 100% of successes can be assured by inoculating rates with *B. lepra murium* provided the appropriate technique is used.

(*c*) The course of the disease in the rat is a relatively rapid one.

(2) As will be observed from the title, we discovered that structures resembling tumour growths occurred in the abdominal cavity following on the intra-abdominal inoculation of rat leprosy. Such tumours, there is reason to believe, are due to multiplication of the peritoneal endothelial cells and phagocytosis of bacilli and the multiplication of bacilli inside cells. We have also remarked on the fibrosis caseation and liquefaction which occurs in the tumours.

(3) We think that a description of the mode of origin of these tumours may help to shed some light on other new growths more obscure in etiology, and also possibly on the pathology of human leprosy.

8. Some observations on the administration of calcium in chronic broncho-pneumonic Phthisis.

P. N. Suri, Lahore.

There is calcium deficiency in the body in tubercular diseases. Mendal reported good effects from the administration of calcium chloride intravenously, while Prest was impressed by the effects of hypodermic injections of collosol calcium in cases of phthisis.

In the tuberculosis wards of the Mayo Hospital, Lahore, observations were made on the administration of calcium salts intravenously, hypodermically, and by mouth, in cases of chronic broncho-pneumonic phthisis. No improvement was observed in the lung lesion, or on the systemic disturbance as shown by the temperature, pulse, or respiration rate ; but in some cases there was improvement in cough with lessening of sputum, as a result of intravenous injections of calcium chloride. Mild cases of hæmoptysis also seem to be benefited by calcium administration.

9. Application of our knowledge of tuberculosis to Indian conditions.

C. Frimodt-Moller, Madanapalle.

1. The decline of tuberculosis in the west and its increase in India. 2. Conditions in India favouring the increase of tuberculosis—(*a*) climatic conditions, (*b*) hygienic and economic conditions, and social customs, (*c*) development of western education and industrialism, (*d*) increased communication. The line of attack on tuberculosis followed in the west and the problem facing India Sanatorium treatment in the west and its value in India. Sanatoria as centres for research work in the treatment of tuberculosis in India—the lines to be followed in this research. Sanatoria as centres for training of doctors in the treatment of tuberculosis in India. Tuberculosis hospitals—cheap and lightly constructed outside larger towns. Bigger hospitals with research facilities in provincial capitals. Tuberculosis dispensaries—their place in India as a later

link in the campaign against tuberculosis. Tuberculosis colonies and the after-care of poor ex-patients. Education of the public by a tuberculosis bureau created for this purpose. Preventive measures against the spread of the disease from industrial centres to rural areas.

10. Sanocrysin treatment of tuberculosis, with special reference to Indian patients.

C. Frimodt-Moller, Madanapalle.

Careful selection of cases is important. When this is observed, and smaller and less frequent doses are given, the formerly very dangerous treatment has now become comparatively safe in skilled hands with a sufficiently careful supervision of the cases which should be treated only in well-staffed hospitals. The results of treatment are encouraging being usually about 50 to 60% improvements. Similar results have been obtained by treatment of 64 Indian patients in U.M.T. Sanatorium. While 26 cases still under treatment and one early case are excluded from analysis, the remaining 37 cases (of which 11 medium severe, and 26 advanced) show 23 or 62% improved. Out of 18 cases in III stage with the course completed 10 or 55% were much improved. Fever disappeared in 13 out of 18 cases confined to bed with fever before sanocrysin was given, although some of these cases had been confined to bed for long time, in one of them even for one and a half years. Sanocrysin should be given to Indian patients in small doses and with intervals of at least 7 days, if no reactions. In some of the cases showing no improvement by any other method and suitable for this kind of treatment, sanocrysin produced strikingly good results. The outlook in the treatment of tuberculosis after the introduction of sanocrysin is brighter and more promising than before.

11. The value of the complement fixation test in the diagnosis of tuberculosis, with special reference to its relation to the tuberculin reaction.

M. Kesava Pai *and* K. Venkat Rau, Madras.

By an improvement in the technique of the reaction we have been able to obtain a larger percentage of positive results in the sera of clinically tuberculous cases and a smaller percentage of positives in the sera of clinically non-tuberculous cases as compared with the results we presented at the Indian Science Congress of 1926. By increasing the incubation period for the first stage of the reaction from 30 minutes to one hour and by halving the amount of the patient's serum in the tubes we have been able to elicit 96% positive reactions in bacillus positive cases and 90% in bacillus negative cases of clinical tuberculosis or 94% positive in all clinically tuberculous cases as compared with 77% positive by the older method. There were 13% only of positive reactions amongst non-tuberculous cases as compared with 32·4% by the older method. There is no relation between the Von Pirquet's reaction and the complement fixation reaction. Clinically non-tuberculous cases giving a strong Von Pirquet's reaction give a negative complement fixation reaction. Whilst 13% of the total non-tuberculous cases give a positive complement fixation reaction, 6·5% only of the non-tuberculous cases giving a strong Von Pirquet's reaction gave a positive complement fixation. It is evident therefore that the immune bodies concerned in complement fixation and in the tuberculin reaction are different. 89% of the surgical tuberculosis cases give a positive complement fixation. About 20% pulmonary cases give a positive Wassermann reaction, indicating a high percentage of syphilis amongst them.

12. The incidence and types of tuberculosis met with in India.

A. C. Ukil, Calcutta.

The study is based on 1,000 carefully performed Cuti-reactions, on the result of examination of 1,670 samples of sputum, on radio-graphic evidence and on *post mortem* data. An attempt has been made to determine the incidence according to professions and to find out the types according to age and sex.

13. On certain aspects of artificial pneumothorax therapy in India.

M. Kesava Pai, Madras.

Diagnosis of pulmonary tuberculosis is rarely made in its early stages in India and hence most cases present themselves for treatment for the first time in the advanced stage of the disease. The material for pneumothorax therapy is thus abundant. The orthodox rules regarding the applicability of the treatment can be relaxed with benefit and many cases with fairly extensive involvment of the collateral lung can be brought under the treatment. Complications like early diabetes, heart disease and pregnancy do not always contraindicate the treatment. The results of pneumothorax therapy in a hospital situated in the busiest and most dusty part of a tropical city like Madras compare favourably with those of sanatoria and hospitals more favourably situated in temperate climates. Of the 182 cases to which the treatment was applied 86% cases in stage II and 75% in stage III were either arrested or had marked benefit from the treatment, whilst 100% cases in stage II and 82% in stage III had benefit of some degree. These figures compare favourably with those of ordinary treatment by which 77·6% cases in stage II and 30·5% in stage III were benefitted. Whilst 53% of stages II and III cases become bacillus negative by pneumothorax treatment, 17·4% only become bacillus negative by ordinary treatment. Pleural effusions are met with in a much smaller percentage of cases in tropical climates than in colder countries, as a complication of pneumothorax treatment.

14. The scope of collapse therapy (Artificial pneumothorax and thoracoplasty) in the treatment of pulmonary tuberculosis in India.

P. T. Patel, Bombay.

Suitability of cases. Places where the treatment is carried out. Special points in technique. Reports of cases.

15. Use of fishes for control of mosquitoes.

S. L. Hora, Calcutta.

During the last four or five years several enquiries regarding the supply of mosquito-larvae eating fish have been received by the Director, Zoological Survey of India. In this note the author has replied to all these enquiries collectively after ascertaining that no organisation exists at present in India that could undertake to supply larvicidal fish except the Department of Fisheries, Madras. But for long distances the cost will work out to be very heavy, since a trained attendant will be required to accompany each consignment. It is, however, advisable to test the utility of the fishes of a locality where it is intended to introduce larvicidal fish. The author has referred to two definite instances of the utility of larvicidal fish in dealing with the problem of the control of

mosquitoes. Extensive field observations are, however, urgently needed on the point and it is hoped that a fair chance will be given to our friends of the finny tribe when this problem comes to be seriously considered in this country.

16. Physiology of the coronary circulation.

E. W. H. Cruickshank, Patna.

To determine changes in the coronary outflow and inflow, the hot wire, which has had such an extensive application in the determination of changes in air velocities, was used. The coronary outflow was determined by placing a Morawitz cannula in the coronary sinus, the inflow by means of a cannula in the brachio-cephalic artery by which the coronary arteries were placed in connection with the perfusion reservoir. Simultaneously with the hot wire records of coronary outflow and inflow, optical records were taken of changes in intra-auricular, intra-ventricular and aortic pressures, and these were also further related to electro-cardiographic records taken by direct leads from the heart. By these means it was found that the deflections on the curve of the coronary outflow bear certain definite relations to events occurring in the heart within one cardiac cycle. They are: a first positive auricular wave, which is due to auricular contraction and bears a definite relation to the 'a' wave of the intra-auricular pressure cure, a negative wave which varies in extent and is followed by a third or isometric wave. This wave is synchronous with the 's' wave of the electro-cardiogram and with the 'c' wave of the auricular pressure curve. It was termed the isometric wave because of its definite relation with the isometric period of cardiac contraction. The fourth or ejection wave—this phase of coronary outflow is not accurately synchronous in its commencement with the beginning of isotonic contraction, although under certain conditions, such as increase in arterial blood pressure, and increase in heart rate, it tends to become so. This wave has been shown to be due to the isotonic contraction of the heart, and terminates with the onset of diastole. The fifth wave marks the phase of filling of the coronary vessels. It has clearly been shown that coronary inflow is a post dicrotic event, it begins during the period of isometric relaxation. From this research it is concluded :—that the changes in the coronary circulation during a cardiac cycle are not due to changes within the first part of the aorta during cardiac systole; that the coronary outflow is maximal during ventricular systole and is diminished if not abolished during diastole; that the coronary inflow is maximal during the period of isometric contraction; that the coronary inflow is a post dicrotic event depending wholly upon the mean distolic pressure; that the coronary flow in c.c. per minute is not altered in the denervated heart by changes in the cardiac output; that changes in the output in the innervated heart do occasion changes in the minute coronary flow; that in a normally beating heart the coronary circulation is controlled by the central nervous system in which the vagus or parasympathetic nerves control the motor mechanism and the accelerator or sympathetic nerves control the inhibitory mechanism of the coronary vessels.

17. A preliminary note on anaerobic infections in India.

A. C. Ukil, Calcutta.

The paper is based on a bacteriological analysis of 10 cases of gangrene and cellulitis obtained from the hospital and from surgeon colleagues in Calcutta and its suburbs, of which 6 were cases of gangrene following either a street injury, fall from a tree or mill accident, one was of perineal cellulitis following extravasation of urine, one was of abdominal

cellulitis following an operation, one was of diabetic gangrene of the leg and one was a rapidly spreading gaseous and oedematous infiltration of the hand following a prick with an instrument. The anaerobic bacilli isolated were *B. welehii* in 5 cases, *B. vibrion septique* in 2 cases, *B. sporogenes* in 2 cases and a non motile spore-bearing bacillus of mild pathogenicity isolated from the case of abdominal cellulitis. The last has been separately described. The strains, after isolation, were identified serologically and by animal experiments. The aerobic bacteria associated with the cases were *Streptococci* in 7 cases, *B. coli* in 3 cases, *Staphyloccoccus aureus* in 3 cases, *B. proteus* 1 case and *B. pyocyaneus* in 1 case.

18. The absence of specific agglutinins in the blood of healthy carriers of Koch's Vibrio.

J. W. Tomb *and* G. C Maitra, Calcutta.

The common view regarding specific agglutinins in human blood and their use in detecting healthy cholera carriers. Blood of healthy carriers of Koch's vibrio tested for specific agglutinins by Garrow's method.—A table shewing the results of this test.

19. A new conception of the origin of Cholera epidemics.

J. W. Tomb *and* G. C. Maitra, Calcutta.

Present conception assumed existence of permanent carriers of Koch's vibrio. Conception based on the analogy of proven carriers of *B. typhosus*. Asansol Mining Settlement (Bengal) an endemic home of cholera. Two kinds of vibrios found in clinical cholera-(*a*) non-agglutinating (*b*) agglutinating. Non-agglutinating vibrios found constantly associated with sporadic cases of cholera. Agglutinating vibrios found constantly associated with epidemics of cholera. Extended examinations of the stools of cholera convalescents shewed that in 20% vibrios permanently disappeared from the stools in 3 to 4 weeks. In the remaining 80% of cases the agglutinating (Koch's) form changed into the non-agglutinating form within the same period. Extended examinations of the stools of the inhabitants of the Mining Settlement showed that at least 30% are chronic carriers of non-agglutinating vibrios. Cholera stools containing large numbers of Koch's vibrios when introduced into the water of ordinary ground tanks showed a rapid change of Koch's vibrio into the non-agglutinating form (within 12-14 hours). Laboratory cultures of Koch's vibrio introduced into ground tanks similarly lost their agglutinating characteristic within 36 hours. Spontaneous outbreaks of cholera have been frequently observed in the Asansol Mining Settlement, six outbreaks having occurred during the course of the investigation under report. As the writers after extended search have been unable to discover any chronic carrier of Koch's vibrio in the Mining Settlement and as no such carrier has even been found by any other observers elsewhere they have been driven to the conclusion, in consideration of the observations recorded above, that spontaneous outbreaks of epidemic cholera are primarily due to infestation with non-agglutinating vibrios which take on the agglutinating characteristic under certain favourable conditions in the human intestine. This characteristic appears to be an essential factor for the spread of cholera in epidemic form. The writers have also good grounds for believing that the epidemic season (or seasons) in any locality will be found to be connected with the annual season (or seasons) of maximum infestation of the drinking water supplies with non-agglutinating vibrios independently of actual outbreaks of cholera.

20. A preliminary note on the treatment of Cholera at the Puri cholera hospital by the serum of convalescent patients.

P. N. Das *and* S. C. Basu, Puri.

Serum, plasma and whole blood of convalescent patients have lately been used as a preventive and curative treatment for measles and scarlatina in Germany and America. Method of preparation of plasma with chinosol as preservative as used by Park and Freeman. Unit of antitoxin is taken as the amount which gives complete neutralisation of the skin test dose. (Henry & Lewis.) Modinos used the blistering fluid of convalescent patient as a prophylactic vaccination for measles. Hypertonic saline permanganates reduced the mortality from 60—70% to 20—25% at the Puri Cholera Hospital. Serum of convalescent cholera patients has been tried in 22 patients in Puri Cholera Hospital. Dose 2 to 3 c.c.. With serum treatment, there was no mortality among patients whose specific gravity of blood did not exceed 1064. With saline treatment alone, the mortality has been found to increase in geometrical progression with increase in the specific gravity of blood. Mortality rate with serum saline treatment 13%. Mortality rate with saline alone 33%. Average mortality during Car festival July 1926, 26%. No conclusion can be drawn from treatment of 12 cases only. The results are encouraging and warrant more extensive trial.

21. The role of certain Gram-negative non-lactose-fermenting Bacilli in the causation of bacillary dysentery in Bengal.

A. A. Ukil *and* A. K. Sen, Calcutta.

The study is based on 60 strains of gram-negative, sluggishly or actively motile, non-lactose-fermenting bacilli, which were isolated from acute cases of bacillary dysentery showing the characteristic cellular exudate and reaction. A uniform technique was followed for their isolation (a modification of Whitehead and Kirkpatrick method). The strains were tested for their fermentative and biochemical reactions, and were tested serologically against para-typhoid B. and Enteridis Gäertner sera, for all of them fermented glucose with gas formation. Twenty strains, which were tested for their pathogenicity, were found to be toxic towards small laboratory animals. An attempt has been made to classify them. The author believes that a large percentage of these bacilli, which have also been isolated during short epidemics in the early stages of illness, play an important role in the production of clinical bacillary dysentery in Bengal.

22. The action of tropical sunlight on bacteria.

A. C. Ukil, *and* M. M. Basu, Calcutta.

The work was undertaken to determine the action of sunlight on pathogenic bacteria in the tropics. The experiments were performed during the months of March—June in Calcutta, when the temperature varied in the open sun, between 40°C to 55°C. The lethal point of each strain, after exposure to direct sunlight, was determined by following an uniform technique. The data have been given in a tabular form. The temperature at the time of experiment was noted in each case. Subsequently, the heat factor was eliminated by two sets of control experiments,—(1) by heating an emulsion of the microbes in water bath for the same period as exposure to sunlight, and (2) by cutting off the heat rays of the sun during exposure. The lethal time was found to be much shorter than European and American data, due chiefly to the chemical

rays of the sun. As regards the action of diffuse light on bacteria, no marked difference was noticed from the data in other countries.

23. The action of certain antiseptics on bacteria.

A. C. Ukil *and* M. M. Basu, Calcutta.

The work was undertaken to find out suitable dilutions of phenol, formalin and chinosol for sterilising vaccines without the application of heat. A uniform technique for determining the lethal point was followed in each case and was applied to almost all the important pathogenic microbes. For microbes which have a special predilection for different regions of the body, more than one strain was employed. The lethal power of each dilution has been given in a tabulated list.

24. A plea for a thorough investigation of the Filariasis problem.

Sir Frank Connor, Calcutta.

Enormous incidence of filariasis. Many gaps in our knowledge. Scattered nature of present inquiries. Need for something on the lines of a 'Filariasis Commission.' Clinical evidence favours view that early treatment is likely to be very successful. Mortality from filariasis, though seldom direct, is probably enormous. Clinical evidence proves that sick-rate involved, and therefore the industrial loss, is very considerable.

25. Some points in connection with maternity and child welfare.

H. G. Stiles-Webb, Nagpur.

Functions of the Ministry of Health. Objects of infant welfare work. Vital Statistics. The vital periods of time—the first month and the first year. Infantile mortality ratio in the various provinces in British India. Infantile mortality ratio in male and female, a comparison and its causation. Infantile mortality ratio in indian cities as compared with rural areas. Maternal mortality and still-births. General summary and conclusions.

26. A silver method of staining Leishman-Donovan bodies in the tissues.

Charu Chandra Basu, Calcutta.

The method is adapted from Gorriz's modification of Bielschowsky-Cajal method of silver staining. The actual process followed has been described, which has enabled the writer to stain not only the reticular tissue of liver and spleen but also the L.D. bodies as well. The advantages of this method over previous ones are that the L.D. bodies are well stained in tissues preserved in formol, the increase of reticular tissue in kala-azar liver and spleen is well demonstrated and the stain is permanent.

27. On the adsorption of chemical elements by bacterial bodies.

N. Banerjee *and* J. K. Basu, Calcutta.

It has been shown by a series of electrostatic experiments that certain bacteria, such as *B. typhosus*, *Streptococcus*, *B. coli*, etc., adsorb definite quantities of such elements and compounds as arsenic, arsenic sulphide and sulphur, etc. The quantity of the adsorbed chemicals has

been estimated gravimetrically and their toxicity assayed on animals. Their action on human ailments is still under trial.

28. Ferro-solvency of drinking waters.

V. Govinda Raju, Calcutta.

Certain waters possess the property of dissolving the material of the iron pipes in which they flow. Under laboratory conditions any water will attack a bright iron surface, whereas in actual practice only certain waters exhibit that power during flow through pipes. This discrepancy is largely responsible for the absence of a clear conception of the causes bringing about ferro-solvency in pipes. In Bengal tube-well waters possess the above property in a marked degree. A critical study of their chemical characteristics reveals the fact that this property could not be due to their softness, their chloride or dissolved oxygen content, or the hydrogen-ion-concentration of the water, as similar quantities of these ingredients are present in other waters which do not exhibit any ferro-solvency. The constant presence of large amounts of carbon dioxide appears to be the factor responsible for the ferro-solvent action. When this gas is present in appreciable amounts the ferro-solvent action takes place irrespective of variations in hardness, salinity, dissolved oxygen content or hydrogen ion concentration. The removal of carbon dioxide by the addition of lime water has in one instance completely eliminated the property of ferro-solvency and appears to be the cheapest and most rational method of overcoming this complaint.

29. Bacteriological efficiency of mechanical gravity filters for purification of water.

V. Govinda Raju, Calcutta.

Systematic monthly examinations extending over a period of two years and occasional hourly examinations during the whole period of a day's run of several filters of the gravity type has elicited the fact that the *B. coli* content of the filtered waters bears a direct relation to that of the feed water and that ordinarily in about 75 per cent. of samples the number of *B. coli* that manage to pass through the filters form about 10 per cent. of those present in the unfiltered water. From this it follows that if one desires filtered water to show no *B. coli* in 10 c.c. the feed water should not contain *B. coli* more than one per c.c. In cases where chlorination is not practised the raw water should be stored sufficiently long to reduce its *B. coli* content to approximately one per c.c.; otherwise the filtered water would not generally show a satisfactory result. These filters show a higher bacterial efficiency during certain times of the year when algal growths are more prevalent.

30. Germicidal power of ethyl alcohol in spirits.

B. B. Brahmachari, Calcutta.

Water used to dilute spirits in country distilleries is of doubtful purity. Experiments were performed to see how far such dilutions are safe to the consumers. Spirits up to 86·3% u.p. were found to be sterile. Dilutions made with grossly polluted water were practically sterile in up to 72·5% u.p. in 24 hours and were free from faecal bacilli in up to 80% u.p. in the same time. In 80% u.p. *V. choleræ* disappeared in half an hour, *B. typhosus* in 1 day and *B. dysenteriæ* (Flexner) in three days. Even in 86·3% u.p. *V. choleræ* did not survive more than 1 day. In 85% u.p. *B. dysenteriæ* disappeared in 6 days, but *B. typhosus* was still living after 9 days and both *B. typhosus* and *B. dysenteriæ* (Flexner) were not killed ln 86·3% u.p. in that period. Experiments with cysts of *Entamoeba hystolytica* are in progress.

31. Food value of the nut of *Trapa bispinosa.*

B. B. Brahmachari, *and* N. K. Chatterjee, Calcutta.

Extensive cultivation of *Trapa bispinosa* has been advocated as a stand-by in famine and as a supplementary food staple. Under its popular name, water nut is liable to be confused with the water chest-nut, a clubrush the tuber of which is eaten as '*Kesur.*' The water nut is *Trapa bispinosa;* a description with plate of the Bengal plant and also analysis of the water in which it grows is given. The cultivation has a serious limitation from the risk it entails of breeding mosquitoes, but the nut grown in an acre of land is worth over Rs. 800 a year. The trapa nut is found to contain all the principles of food ; it is, however, very poor in fat and also in lime. One pound and a half of the nut is found equivalent to one pound of milk in energy value, with slight excess of phosphorus, 4 times the quantity of iron, half that of potash and three times that of soda. The trapa flour or '*palo*' as a farinaceous food compares very favourably with other such foodstuffs. The starch granules are characteristic, oval in shape with a diameter of 30–40, pointed hilum and distinct concentric striae making complete rings. Detection is easy in case of adulteration. Experiment as to whether the protein in it is a 'whole protein' is proceeding.

32. *Psoralia corylifolia* (Babchi). Its chemical composition, pharmacological action and therapeutic properties.

R. N. Chopra *and* N. R. Chatterjee, Calcutta.

Psoralia corylifolia is called *Bukchi* or *Bábchi* in Hindi, *Bauachi* in Bengali and *Sugundha Kantak, Vakuchi* and *Somraj* in Sanskrit. Seeds of the plant have long been used externally and internally in Hindu medicine in leprosy and skin diseases. The seeds contain (1) a fixed oil, (2) a volatile oil to which most of the pharmacological activity of the seeds is due, (3) resin, (4) traces of an alkaloid. The essential oil has well marked antiseptic properties and is irritant to the skin and tissues. Oleoginous extract made from the seeds applied locally helps to clear up patches of leucoderma.

33. Observations on the chemical composition, pharmacological action and therapeutic properties of *Sassurea lappa*-Kuth root.

R. N. Chopra, S. Ghosh, P. De, *and* A. T. Dutt, Calcutta.

Sassurea Lappa is called *Kut, Kot, Kusht,* or *Patchak* in Hindi, *Kushta* or *Kashmirja* in Sanskrit and *Kust* in Arabic and Persian. The best quality of root comes from Kashmir where it grows at a height of 8 to 12 thousand feet above the sea level. The constituents of the root are :— (1) an essential oil with a very powerful odour, (2) an alkaloid occuring in small quantities, (3) a bitter substance of the nature of glucoside, (4) resin, (5) inulin, (6) water soluble bases. The drug has very marked anti-spasmodic properties and is one of the best remedies in vago-tonic types of asthma. An alcoholic extract made from the root was tried in a large series of cases with most satisfactory results. Not only are the spasms relieved but it prevents recurrence of attacks, loosens the phlegm and clears the respiratory passages.

34. Toxicity of mature and immature genuine spirits and Imitation or Factitious Spirits.

R. N. Chopra, Calcutta.

Three classes of potable spirits are now on the market in India. (1) Fully matured spirits which are covered by a certificate of age from the Government to the effect that they were over three years old. These are the most expensive. (2) Genuine but immature spirits which do not hold this certificate. These are cheaper than matured spirits. (3) Imitation or factitious spirits which consist of diluted alcohol so far stripped of the byeproducts by patent still that fermentation base is no longer discernible and certain substances giving the flavour and odour of the genuine spirits are added to it in minute quantites. These are very cheap being about a fourth of the price of the genuine spirits. Consumption of spirits belonging to classes (2) and (3) has been held by some to be much more deleterious to health than those belonging to class (1) and this research was undertaken to determine whether this was so. Thirteen specimens containing representative of all the three classes now offered for sale in India were obtained from one of the biggest local firms and their toxicity was tested on cats. The toxicity of essences used for flavouring the imitation spirits was tested separately. Fully matured and immature genuine spirits and the imitation factitious spirits showed about equal toxicity to cats, ethyl alcohol being mainly responsible for the toxic effect produced. The byeproducts, in the quantities in which they are present, in the immature spirits have little or no effect on the animal organism.

35. The causation of production of cystitis.

Ganapati Panja *and* Kalipada Banerjee, Calcutta.

Samples of urine from 44 cases were collected aseptically and cultivated by an enrichment method. The following is a list of the organisms isolated :—(1) Nonlactose fermenters. *B. asiaticns*—4, *B. proteus* —2, B. *faecalis alkaliges* —2, Total 8. (2) Lactose fermenters. *B. coli communis*—4, *B. pseudo-coli*—1, *B. colotropicalis*—2, *B. cloacae*—1, *B. acidi lactici*—9, *B. vekanda*—3, *B. metadtffluens*—1, *B. meta-dysentericus*—2, *B. entericus*—1, *B. paraentericus* —1, *B. lactis aerogenes*—1, *Streptococci.*—10. Total 36. These are all gut organisms. The mode of invasion of the urinary bladder may be either through the blood as a result of emboli from the intestines due to some intestinal disease or via the lymphatics by migration from some pelvic inflammation. The above findings are quite contrary to the popular view that *B. coli* is the most common offending organism in these chronic cases of cystitis. Treatment consisted mainly in giving autogenous vaccines, dealing with the source of these organisms and increasing the general resistance of the body. Cure was effected in the majority of the cases.

36. A few important facts regarding manufacture of soda-water from the chalk-derived water of a deep tube well.

N. L. Banerjee, Calcutta.

In the manufacture of soda water in tropical climates the lowering of temperature of the water during carbonation has more effect on its gas absorbing capacity than the increase of pressure. The usual addition of 'soda salt' to the water besides imparting the characteristic taste to soda water does not help materially to increase its carbon dioxide content. A water containing chalk from a deep tube well such as at Calcutta

having a high temporary hardness should be softened with lime before it can be used for the manufacture of soda water. The quantity of lime to be added for this purpose is to be calculated after determining the saline constituents and the amount of carbon dioxide originally present in the water. This quantity is also just enough to eliminate all the temporary hardness of the water in actual practice. Any deficiency or excess of lime over this amount is derogatory to the gas retaining power of the water. The water thus softened has got a greater gas absorbing power than the raw water and the soda water made from it has also the same characteristic taste as that made from the raw water to which the 'soda salt' (soda bicarbonate) has been added. The use of the latter salt which is rather costly can thus be obviated.

37. A new method of determining temperature of small insects.

H. W. Acton *and* S. K. Mazumdar, Calcutta.

A new method has been proposed to determine the temperature of small insects, such as the cockroach, bed-bug, fly, and mosquito, etc. The investigation is important from the point of view of flagellation of the malarial parasites. Thermocouples made of copper and constantan wires of varying thickness from 30 to 40 S.W.G. were employed, in conjunction with a rheostat and delicate galvanometer, the deflection of the latter on a fixed scale being taken, within short range, to be proportional to the E.M.F. developed in the couple. The fine end of the couple lay within the insect while the other end was kept in a specially protected calorimeter, the temperature of which could be regulated. By adjusting the temperature of the water in the calorimeter, the point was noted at which the direction of deflection was reversed which corresponded to no E.M.F. and therefore equality of temperature in both the junctions. The insect was subjected to varying external temperatures from 15°–40°C., by adopting a special device.

The results reveal the interesting fact that at ordinary temperatures, there is an undoubted lag behind the temperature of the environment. This discrepancy increases with the rise of temperature and vice versa. For these 'cold-blooded' insects therefore, we may suppose, that there is a limiting temperature, above which there is a lag behind the outside temperature, but below this point loss of heat by evaporation cannot counteract the metabolic heat production.

38. Relationship of the colour of rabbits to their susceptibility to Insulin.

H. W. Acton *and* J. P. Bose, Calcutta.

Rabbits of different breed and colour used for physiological assay of insulin behaved quite differently with the same dose of insulin injected. This variability is closely correlated to the colour of the animal tested; the albino white rabbits were least affected by insulin while the brown belgian hares were most susceptible and more than 75% of them suffered from severe hypoglycaemic reactions. The jet black and the piebalds come intermediate between the albino himalyan and the brown belgian hares as regards susceptibility to insulin. Small doses of adrenalin inhibit the action of insulin by causing hyperglycaemia and when adequate doses of adrenalin and insulin were simultaneously given to the same rabbit, there was neither rise nor fall of blood-sugar. It is quite possible that the colour variability in rabbits is associated with variation in the adrenalin content in these different species of rabbits which might account for the difference in the behaviour of these animals to the same dose of insulin.

39. Production of oriental sore in man by flagellate culture of *Leishmania tropica.*

Ganapati Panja, Calcutta.

A patient (volunteer), aged 30, living in Calcutta for 15 years, was inoculated intracutaneously on a part on the back which was covered by clothes, twice at the same spot at an interval of a week with a week-old flagellate culture of *Leishmania tropica.* A small nodule developed in about 2-3 weeks at the site of inoculation. It became bigger when the patient went to Kathiawar in May about 9 months later. It ulcerated after 3-4 months when in Kathiawar, i.e. a year later, and showed the characteristic appearance of an oriental sore. A smear-examination was made and a large number of *Leishmania tropica* parasites was found. Applications of carbon-dioxide snow cured the ulcer.

40. Observations on the tuberculin test, with special reference to the intradermo-palpebral tests conducted with the ordinary concentrated tuberculin and concentrated avian tuberculin for the detection of tuberculosis and Johne's disease in cattle.

V. Krishnamurti Ayyar, Madras.

The author records his observations on the tuberculin tests conducted at the Madras Veterinary College. The tuberculins used in all the tests recorded were obtained from the Imperial Institute of Veterinary Research, Muktesar. Both the intradermo-caudal test and the double intradermal test as recommended by the Medical Research Council in England have proved of great value in the detection of tuberculosis in cattle. There is, however, no distinct advantage of the double test over the single test. The test that has been recommended by Edwards as having given promising results in the detection of either tuberculosis or Johne's disease in cattle is the intradermo-palpebral method carried out with the concentrated avian tuberculin and ordinary concentrated tuberculin. This test as described by Edwards was conducted on healthy as well as tuberculous animals and animals definitely known to be affected with Johne's disease. By this test the reactions obtained with the ordinary tuberculin in tuberculous animals are quite similar to those one obtains either in the intradermo-caudal test or double test except that the swellings persist for a longer time in the latter tests and appear on the whole to correspond to those described by Moussu. The reactions with the avian tuberculin are always more pronounced than those with the ordinary tuberculin in tuberculous as well as non-tuberculous animals and the swellings reach the maximum in non-tuberculous animals within 6 hours after injection and disappear in 24 hours. In the detection of Johne's disease, the writer considers that avian tuberculin is of little value and agrees with the observation made by Twort and Ingram, 'the use of avian tuberculin in Johne's disease has been proved to be practically worthless'. The writer also records that though all the animals that were injected intravenously with the avian tubercle bacilli reacted to avian tuberculin except one when tested a year after no evidence of tuberculosis could be detected in any of those that were destroyed to verify the reactions. The failure to find any lesion in these animals is quite in accordance with the findings of Sir John McFadyean and his colleagues. A detailed description of the reactions of the different tests conducted as well as the post-mortem notes on the animals destroyed to verify the test are recorded in the paper.

41. A note on the occurrence of carcinoma among cattle in the Madras presidency.

V. Krishnamurti Ayyar, Madras.

Carcinoma appears to be a very rare condition among cattle in other countries. In the Madras presidency, the affection seems to be widely prevalent, the lesions being commonly found affecting either the eye or the horn core. Sections cut from the lesions reveal them microscopically to be squamous epithelioma. The number of cases confirmed as epithelioma in human beings microscopically at the Madras Medical College Pathological Laboratory during a certain period is compared with those confirmed in animals at the Madras Veterinary College Laboratory during the same period. The data appears to indicate that the incidence of epithelioma in animals is of the same extent, if not more, as compared with human beings. A statement showing the details of the cases confirmed in animals is appended to the paper.

42. A note on the incidence of tuberculosis among cattle of the Madras Corporation and their susceptibility to tuberculosis.

V. Krishnamurti Ayyar, Madras.

From the available evidence it would seem that the incidence of tuberculosis in cattle in India is low. At the Ferozepore slaughter house where a systematic examination of carcases was undertaken, the incidence was found to be about 3·5 %. In most of the cases recorded including those examined by Glen Liston and Soparkar in the outbreak among animals in the Zoological Gardens, Bombay, the lesions had been found practically localised and confined to the thoracic cavity. Some experiments had been conducted by Glen Liston and Soparkar at the Haffkines Institute, Bombay in 1917 and by Sheather at Muktesar in 1920. While the results of Glen Liston and Soparkar go to show that the infrequency of the disease among cattle in India as compared with England is due rather to their natural resistance than to any special method of housing or keeping cattle in India, those of Sheather appear to indicate that the strains of organism isolated from the material supplied by Taylor from the lesions found among cattle slaughtered at the Ferozepore slaughter house are of a relatively low virulence. In a paper read by Soparkar before the Indian Science Congress held in January, 1926 which embodied the results of his investigations conducted at Muktesar among most of the important breeds of cattle in India it is mentioned that a certain proportion of Indian calves as well as even cross-bred calves showed a high resistance to infection. In Madras, the first case of tuberculosis was recorded in the Corporation cattle in 1916 and since then the incidence of the disease among these cattle has been on the increase year after year. During the course of last official year 1925-26 the disease was confirmed in 22 animals and in all those that came under the writer's observation the lesions found were invariably generalised, the special feature being that in addtiion to the presence of lesions in the thoracic cavity, the mesenteric glands were found invariably affected and in many cases characteristic ulcers in the intestines and involvement of the kidneys were also noticed. In some of the animals tubercle bacilli were detected even in the urine during life. During this year up to 1st November 1926, 12 more cases have been confirmed and among these is included a male buffalo. The nature of the above lesions appears to indicate that the disease as met with among these cattle is of a very intense type and differs in no way from what is found in English cattle and that the incidence is due to the conditions in which these cattle are kept which favour the spread of infection. The writer is

of opinion that the main reason for incidence of the disease being so low in India is that the conditions in which cattle are generally maintained in this country preclude the spread of infection and that with the establishment of conditions favouring the spread of infection from animal to animal, the problem of tuberculosis infection would become a serious one as has occurred in the Madras Corporation cattle depots.

43. Sarcoids or acquired angeiomata.

H. W. Acton, Calcutta.

These angeiomatous new growths which were somewhat similar in their histological structure to congenital naevi, were observed fairly frequently amongst patients suffering from epidemic dropsy during this last epidemic (1926). The name sarcoid was first introduced by Boeck, and is an ill-adapted name, for it suggests the possibility of malignancy. The term angeiomata is more appropriate as it defines the nature of these cutaneous lesions. Three clinical types are described. Tache de Morgan, a small flat angeioma which Morgan thought was associated with cancer. The nodular type of Boeck. Plaque type of Darier Roussy. The nodular type was the one that was observed in these cases of epidemic dropsy, and their histology is described. The production of hypertrophy of the vascular endothelium as the result of the action of these rice toxins which only occurs in certain individuals opens out a new idea as to the causation of certain innocent tumours.

44. The causation of epidemic dropsy.

H. W. Acton *and* R. N. Chopra, Calcutta.

In January 1925, we jointly published in the Indian Medical Gazette a paper on the 'Causation of Epidemic Dropsy,' in which we attributed the disease to the production of toxins in the rice as the result of an attack by a Bacillus belonging to the vulgatus group. This work explained most of the cases of the disease, but left three important questions unanswered. Could infection take place from man to man? The disease still occurred in spite of the change in the diet to a healthy rice. What was the cause of the fever that was so often associated with the disease? This year's 1926 epidemic strengthened our original idea that the majority of cases of the disease were due to an infection of the rice by improper storage. There were also undoubted cases of infection from man to man. The stools of infected individuals were examined and found to contain almost a pure culture of a large gram-staining bacillus similar to the rice bacillus. These bacilli would not grow on McConkey's media but only on ordinary agar, and were identical with the bacillus cultivated from inside the grains of diseased rice. It is conceivable that such bacilli could be transmitted from individual to individual with very intimate contact, handling food etc. As bile inhibits the growth of these bacteria, they could only survive and multiply above the papilla of Vater, and in this way act on the healthy rice eaten by the individual. Cultures made from the urine showed various intestinal organisms and streptococci, indicating that with the damage to the surface epithelium of the gut, these organisms can invade the blood stream, and are excreted by the kidney, thus explaining the fever. We were fortunate to obtain a partial postmortem, and the lesions of the main organs are described for the first time.

45. Puerperal Sepsis.

C. A. F. Hingston *and* A. Lakshmanaswamy, Madras.

General principles adopted. Prophylaxis. The place of the vaginal and intra-uterine douche in puerperal sepsis. Curettage and Ecouvil

lonage. Postural treatment. Complications of the bladder and kidney. Serum and vaccine therapy. Their value and place in the treatment of puerperal sepsis. Operative treatment. Treatment of complications. Some notes on the bacteriology of puerperal fever. Organisms present. The role of *Streptococci* in puerperal fever. The varieties of *Streptococci* present. Their relative severity in puerperal sepsis.

46. Puerperal Eclampsia.

C. A. F. Hingston, *and* A. Lakshmanaswamy, Madras.

Incidence of the disease. Distribution according to age and number of pregnancy. Some clinical features noticed. Complications: Principles of treatment adopted. Blood pressure and its relation to prognosis. Methods of reducing blood pressure. The effect of veratrone. The treatment of labour. The treatment of complications. The results in 250 cases with some note on prognosis.

47. Tropical Neurasthenia.

H. W. Acton, Calcutta.

The word "neurasthenia" to the sufferer means a life which is crowded with anxiety owing to the dread of disease or death, and is associated with debility and the consequent feeling of ill health. All these real symptoms are without any obvious cause, and consequently the patient becomes introspective and seeks to find a cause by the onset of heart disease, cancer, etc. The physician however views the condition rather, light heartedly and dismisses it with the diagnosis that it is due to nerves and advises them not to worry but to take medicines containing vile drugs like asafoetid combined with bromides.

What I desire to show is that neurasthenia is a real condition, due to certain external and internal causes which are more prevalent in the tropics. Neurasthenia cannot be cured by palliative treatment. In the tropics the main exciting causes are the acute diseases like, typhoid, plague, smallpox, etc., or what is more common an interference with the gut functions, as the result of dysentery, etc. Besides these main exciting causes there are certain predisposing causes such as, exhaustion by excessive work, high temperature, lack of ventilation or the poor quality of the food. For about 8 months of the year the quality of the meat and vegetables is very poor and the variety very limited, and the excessive use of fat in cooking, especially, mustard oil all help to ruin digestion and produce hyperchlorhydria, and sometimes ulcers of the duodenum. The effect of these toxins or interference of nutrition first falls on the thyroid gland with the result that the basal metabolism is lowered and the patient feels dull and apathetic. The interference with the basal metabolism and lack of nutritive substances in turn hinders the functions of the adrenal glands. The adrenal deficiency affects the functions of the gonads, which shows different effects in the male and female. As a result of these disfunctions the mind becomes introspective, trying to find the cause and fixes on all the various functions of the body, whichever becomes irregular in action then the mind is focussed on it and disease is feared in that part of the body.

The treatment is not by simply giving the patient a bottle of bromide and telling him not to worry, but requires a good deal of forethought and examination before the exciting cause may be arrived at by the physician. After this the predisposing causes have to be considered as well, and sometimes a change of environment is very necessary. Finally the endocrine function which is deficient should be stimulated by endocrine therapy.

48. The primary investigation into the cause and aetiology of filarial lymphatic obstruction.

H. W. Acton, *and* S. Sundar Rao, Calcutta.

The result of the work has been the united experience of both authors during the last five years at the School of Tropical Medicine, and has involved the examination of some 800 individuals.

The geographical distribution of the disease was found to be along the sea-board of the Bay of Bengal, Indian ocean, and also along the course of the Ganges.

As regards the aetiological factors, the commonest age at which the lymphatic obstruction appears is about 20 years of age, which means that usually a continued period of residence is necessary in an infected area before symptoms appear. For this reason the disease is thought to be rare amongst Europeans, but is purely due to the fact that they rarely reside continuously for 15 years in an infected area. The causation of lymphatic obstruction is not due to the filaria, but to the bacterial emboli which select the dead filaria as a nidus, and thus gives rise to various types of streptococcal or staphylococcal infection that is seen in this disease. The common source of the nidus is from pyorrhoea and from gut infections. Such people have repeated attacks of acute inflammation and very soon develop elephantiasis. The micro-filarial rate amongst such individuals is lower than the normal rate amongst the general population, and shows, that when elephantiasis develops the micro-filaria usually cannot find their way into the blood stream.

The relationship of the development of the adult larvae in the mosquito has been studied, and found to be the shortest during the months of July, August, and September. At this period the larvae will readily penetrate the skin, but during the winter months the development in the adult larvae is slower and the adult larvae fail to penetrate the skin. One therefore can see excessive moisture, such as occurs during the monsoons in the sea-board areas and along the course of great rivers, is very necessary for infection to occur.

At present there is no drug that can kill the adult filaria, all the commoner ones such as, As., Sb., Hg., Bi., and various combinations of these salts with silver and mercurochome have all been tried. One must, therefore, rely on the prevention of infection during the monsoon months.

This destruction of the septic focus to prevent inflammatory attacks and softening of the inflammatory tissues by vaccine therapy.

49. Biochemical reaction of the organism of bovine lymphangitis.

V. Krishnamurti Ayyar, Madras.

50. Globulins in Kala-azar and Syphilis.

Charu Brata Ray, Calcutta.

Protein constituents of blood serum have been known to be albumin and globulin in the ratio 1 : 1. 5.

Globulin is subdivided as globulin proper, pseudoglobulin I and pseudoglobulin II. There is an increase of globulin in both kala-azar and syphilis. This has been shown to be the case by serum analysis. In kala-azar the albumin content goes down generally but the globulin content proportionately increases. The most marked increase being in the euglobulin factor. This pathological deviation is a constant factor. But in other forms of Leishmaniasis, namely Delhi boil, there is no marked change in the results of serum analysis. Again it is shown that the various clinical

means of diagnosis of kala-azar except the findings of the *Leishman-donovan* body depend on this increase of globulins.

Suggestions are offered as to the probable source and significance of globulins. In Syphilis the serum changes are found to be somewhat altered to those of kala-azar. Here also the globulins are markedly increased, but this increase is shown to be, on the other hand, to the pseudoglobulins.

The Wassermann reaction is shown to be due to this increased globulin content and not due to the increase of the other chemical substances, e.g. cholesterine, lipoids, etc. An explanation is given of the using up of the complements in this reaction and it is thought that the globulins of the leutic serum are really the so called anti-bodies.

51. A preliminary note on the pharmacological action of Conessine, the alkaloid of *Holarrhena antidysenterica.*

R. N. Chopra, J. C. Gupta, J. C. David *and* N. N. Ghosh, Calcutta.

Holarrhena antidysenterica is called '*Karchi*' or '*Dudhi*' or *Indrajab* in Hindi, '*Kurchi*' in Bengali, '*Indrayav*' in Sanskrit, and '*Inderjave-Talkh*' in Persian. It is a small deciduous tree which grows on the tropical Himalyas and throughout the dry parts of India. The bark of both the stem and the root, and the seeds are considered to have powerful antidysenteric properties by the Hindu physicians and they largely use it in the treatment of dysentery. The pharmacological actions of the alkaloid, conessine have been investigated.

52. Effect of injections of unsaturated fatty acids on Chyluria and Lymphorrhagia of filarial origin.

K. K. Chatterjee, Calcutta.

Varicocity of lymph vessels is one of the results of filarial infections The vessels are elongated, they become tortuous, and their walls become thin. Lymphangiectasis of the spermatic and other lymph vessels and varicose condition of other lymph vessels have been described. A similar condition is produced in the scrotum known as lymph scrotum. A characteristic feature is the formation of vesicles, which rupture and give rise to lymphorrhagia. In order to ascertain what effects may be produced on chyluria and lymphorrhagia by the introduction of unsaturated fatty acids, I gave intravenous and intramuscular injections of ethyl ester margosic in some cases. The effect was as follows: at first there was an increase in the amount of chyle in the urine and of the flow of lymph from the elephantiasic tissue; later, the chyle and lymph became thicker and thicker till the flow ceased. The object of my short paper is to invite investigations on these lines, in order to study the bio-chemical changes that are produced, also to see what therapeutic effect if any is likely to be produced by this.

53. Observation on the pathology of Amoebiasis.

K. K. Chatterjee, Calcutta.

Amoebic infection takes place by the blood stream and the lymphatic route. There is disintegration of tissue (cytolysis) and liquefaction resulting in the so-called amoebic suppuration; if it is of a chronic type there is cellular proliferation and fibrosis. This latter change, i.e. fibrosis or cirrhosis usually seen in the more chronic type of infection is at least partly due to toxins liberated by the living amoebae or the disintegration products of the dying or dead amoebae. It has thus been pointed out that cirrhosis of liver is sometimes caused by chronic hepatic amoebiasis.

The so-called capsule of an amoebic liver abscess consists mostly of fibrous tissue, whereas the pathological process induced in the tissues parasitized by *E. histolytica* is a solution of the tissues by a process of cytolysis. Thus there is concurrently a process of fibrosis in the surrounding tissue, the extent of fibrosis depending on the degree of induced tissue reaction. The interest of my paper is centred in the study of the slow and gradual process of fibrosis in the peripheral zones of the organs invaded by *E. histolytica* which often extends to the contiguous tissues and organs. There is evidence of exudation and cell proliferation caused either by the *E. histolytica* or a substance of a toxic character or both carried to the surrounding tissues mainly by the lymphatic route. They often produce clinical phenomena which are of some importance from diagnostic and operative points of view. In some cases they have simulated duodenal ulcers, appendicitis, cholecystitis and cholelithiasis and biliary colic; in other cases they have either simulated peritonism and ilius or have actually given rise to these conditions. In other cases again they have simulated nephroptosis and visceroptosis. In some cases they have given rise to formation of abscesses which are often retrocoecal and retrocolic in situation, without evidences of communication with the lumen of the gut.

54. A simplified cold incubator keeping a temperature of 22°C.–25°C.

A. C. Ukil, Calcutta.

The apparatus consists of an ordinary insulated wooden box with two chambers, higher and lower. The higher chamber holds ice and serves for the conservation of bacterial strains, sera, antigens, etc. The lower chamber is about a foot in height and serves as the cold incubator. The melted ice in the upper chamber, before it flows out, circulates through 2 coils of copper tubes over the lower chamber. No regulator is required in winter and the temperature can be regulated easily in summer by means of a regulator.

The incubator has been utilised in culturing *Leishman-Donovan* bodies and for gelatin plate cultures in water bacteriology. It can also be utilised in the outlying areas in the tropics for drying the spinal cord for the Pasteur treatment of rabies. The initial and operating costs are small.

55. On the action of Cobra-venom on heart.

N. M. Basu, Calcutta.

Cobra-venom is used as a heart stimulant in Aurvedic system of medicine. Several years ago I received '*Suchika-Varan*' (the name of the Kaviraji medicine containing cobra-venom) from a big Kaviraji firm but found to my utter surprise that the sample had no action on heart. Last year I secured a good sample of cobra-venom, and found that strong solutions of cobra-venom have an inhibitory effect on frog's heart, but when the solution is very dilute, it causes a marked acceleration and augmentation of heart beat and at a slightly higher concentration it augments the auricular contraction but inhibits the ventricular contraction. When the strength is further increased the auricles are also inhibited.

56. Some observations on the treatment of Asthma.

H. Ghosh, Calcutta.

Aetiology—Various factors concerned—Secondary role of microbic infection in chronicity of asthma. Presence of bronchial spirochaete and fusiform bacilli.

Treatment with sulfarsenol and autovaccine in longstanding cases. Non-specific stimulation therapy-Indications for use of sulphur.

57. On the increase of mortality due to tuberculosis in this country by massive infection.

GOPAL CHUNDER CHATTERJEA, Calcutta.

In european countries e.g., in France, it has been shown that to prevent high death rate from tuberculosis, the easiest way is to lay greatest stress on prevention of massive infection. How is massive infection caused ? Examples of massive infection. Effects of massive infection. Suggested remedial measures by which this can be prevented. Discussion.

58. Some factors which influence the incidence of Leprosy.

E. MUIR, Calcutta.

The chief direct causes of high endemicity of leprosy in India are dietetic, the poor diet available being supplemented by decomposing fish, meat, rice, etc. Caste and race have a certain bearing due to habits regarding diet and to certain aboriginal tribes being driven into the less fertile tracts or into serfdom or debt. The poor soil of certain tracts, its porosity and the slope of the land are of importance, as the crops are correspondingly poor or precarious and dietetic errors result. While a very low humidity makes for a low incidence of leprosy as shown by Sir Leonard Rogers, this survey has not shown a close correlation between humidity and leprosy. Excessive rainfall by washing away and impoverishing the soil by leading to mosquito-breeding and malaria (and in other ways) may have an indirect effect.

59. Constants of pure cow ghee.

B. B. BRAHMACHARI, Calcutta.

Adulteration of cow ghee is very frequent. Fifty-two samples have been analysed. The Butyrorefractometer reading, though of some help in sorting is useless even as a corroborating evidence of adulteration. Saponification value of the ghee is found positively correlated with its Reichert Wollny Value practically completely, and Iodine value, with the saponification value negatively also almost completely. These values as associated with the Reichert Wollny value are upset in case of adulteration with articles having no fatty acids or with higher saponifiation values, so that we find that we can detect such adulteration even when the Reichert Wollny value remains within the range found or even higher than 24 c.c.

60. The distribution of hymenolepis infections in India with a discussion of its epidemiological significance.

ASA C. CHANDLER, Calcutta.

Review of recent work on the lite cycle of *Hymenolepis nana* and of the relationship of the dwarf tapeworms of rodents and man. The distribution of the human parasite in India is very irregular. It is rare in Burma, Assam, Bengal and Orissa, and very common in the Punjab, Sindh, Gujerat and Central India, up to over 20% in some localities. Its distribution is almost directly opposite to that of Ascaris and Trichuris which are coprophagous infections, and closely parallels that of plague, taking into consideration the special climatic conditions which affect plague. This strongly suggests the acquisition of infection from eggs of rodent rather than human origin.

61. The chemotherapy of Surra (*Trypanosoma evansi* infections) of horses and cattle.

J. T. Edwards, Muktesar.

A summary of the results of experimental observations at Muktesar

62. A new species of *Dipyledium* Leuckart, 1863, from a Siamese Cat.

Amarnath Gulari, Muktesar.

63. The chemotherapy of Trypanosomiasis, with special reference to Surra.

S. K. Sen, Muktesar.

64. Opium addiction.

R. N. Chopra *and* Khem Singh Grewal, Calcutta.

An analysis of 100 cases of addicts among the Shikh population of Calcutta.

Section of Anthropology.

President:—J. H. Hutton, Esq., M.A., D.Sc., C.I.E.

Presidential Address.

Anthropology and Administration.

As I am not the first district officer to have had the honour of occupying this place, there is perhaps no need of an apology for the anomalous usurpation of a pandit's throne by a man of affairs. If any justification were needed, I should look for it in the fact that a district officer who is also an anthropologist is in the fortunate position of having, as it were, a footing in two opposing camps. For it must be admitted that in anthropology, as in other directions, the bond between Science and the State is not so close as reason and expediency would seem to demand. The State has always distrusted science, and under the banausic conditions of latter-day politics the proletariat dislikes the genuine intellectual as much as the tyrant and the oligarch have done in their day. Napoleon could not bear what he called *idéologues*, though he did not actually persecute them, but Russia makes pogroms of her intelligentsia, while even the U.S.A. prosecute theirs. Indeed, this is perhaps but part of a general world movement, for even psychology nowadays tends to exalt kinaesthesis to a level with the recognized methods of intellectual activity.[1]

Of course this attitude is not without some justification. It was said of the Athenian, the cream of Greek intellectuals, that he was *πρὸς ἅπαν ξυνετὸς ἐπὶ πᾶν ἀργός*—"in everything enlightened, and at everything ineffectual." Many of us will recall from undergraduate days a certain almost contemptuous distrust of dons as a class, whatever our feelings for particular individuals, and this, I take it, is merely another symptom of the same general idea. A recent writer has stated that in France intellectual influence was at its strongest in politics from 1875 to 1905, and that those thirty years witnessed "a shrinkage in political virtue, a lowering of the national pulse; a gathering indifference to national name, fame and heritage," and that "If France awoke again.....it was because she has listened, not to the intellectuals, but to those who have rebelled against their doctrines."

Still there is a great deal to be said on the other side for the

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[1] See T. H. Pear, *Remembering and Forgetting*, ch. xii, 'The Respectability of Muscular Skill.'

scientist. He is at least the first man to reach the socratic stage of knowing enough to be aware that he knows nothing, and even if it be objected that the mental attitude of a man of science will lead to a doctrinaire and academical spirit useless for practical administration as engendering weakness and indecision, it can at least be claimed that one of the leaders among recent anthropologists, the late Dr. Rivers, recognized the danger, and would have been the first to condemn any course that created such an attitude. [1]

It cannot be denied, I think, that both Governments and Missionaries, who must, at any rate for the purposes of this discussion, be reckoned with administrators rather than with scientists, have not infrequently pressed their side of the case much too far; their outlook is too apt to be obscured by ideas of efficiency, philanthropy, "civilization" and "progress," not to mention religion; they have their minds already occupied, to quote Rivers again, "with an organised body of knowledge, the fruit of the gradually acquired experience of those who have been concerned in the work of government in the past. It is in the satisfaction of rulers with this knowledge and in their failure to recognise its incompleteness, and even its too frequent falsity, that there lies the chief obstacle to the recognition of the value of science in their work." [2] When truths which clash with the methods based on such a body of knowledge are brought to notice, they are perhaps too ready to say that the necessities of administration, or ministration as the case may be, are in conflict with the anthropologists' view and that the latter must go to the wall. "Earth on the eyes of Oran!" is really their cry. It is so much simpler not to know that you are wrong.

Let it be granted, however, that everyone distrusts a professor, and none more so than other professors; let it be granted that all scientists are suspect; do they not foolishly ensue knowledge for its own sake regardless whether it be of any practical value? Nevertheless, some knowledge of anthropology is in truth very necessary for all those branches of administration which entail the control by a highly civilized race of another race whose culture is what is commonly called 'primitive.'

Damage enough has been caused to subject races by deliberate cruelty and hostility arising from a complete divergence in ideas and a conflict of material interests. The pitiable cases of the Tasmanians, the Bushmen, the Hereros, the Easter Islanders occur to one at once, and the list could unhappily be considerably extended. But it has not been by blood and

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[1] See W. H. R. Rivers' *The Government of Subject Peoples*, in *Science and the Nation* (p. 324). Cambridge, 1917.

[2] Rivers, *loc. cit.*, p. 307.

thunder alone that primitive races have been exterminated. Ignorant and arrogant attempts to "improve" have probably done almost as much to destroy native races as the cupidity and prejudice of amateur boanerges, possibly even more. After the last Tasmanian war, everything that could be thought of for the welfare of those who had survived extermination was attempted, but it took the remnant only forty-five years to become extinct under the aegis of civilization. Rivers' examination of the causes of the depopulation of Melanesia is well known, and, as a result of their contact with more civilized races of both east and west, the Marquesans and the Caroline Islanders have likewise almost died out. And we read of the Eskimo "the intrusion of the white man has brought with it the usual blight—poverty, sickness, selfishness and loss of self-respect."[1] Nor can the Indian expect to escape the same censure as the European, since from the point of view of the bottom grades of society caste has been a greater enemy of self-respect than colour or wealth.

A race adapts itself through many generations to its environment; then comes a civilized intruder and finds its customs strange, uncouth, repulsive perhaps. Regarding such customs as bad from its own point of view, it conceives of them as bad in themselves, and promptly starts a policy of destruction in the belief that it is substituting higher and better ways. The destructive programme is easy enough; the customs and their sanctions that held society together are obviously powerless to bind the intruders, their value is not realized and they are too lightly cast away. The construction of substitutes is, however, quite another thing, and the far too frequent result is a rapid moral and physical decline, following on a decay of the bonds which have kept the community solid and healthy in the past. Civilization is, as it were, a drug, which however harmless or even beneficial to the hardened and immune, is a rapid poison to those unaccustomed to its use. It is no less destructive than opium or alcohol, and like them needs to be controlled, and that straitly, in the interests of the weak. Unhappily the poisonous nature of the drug has been far too little realized, and philanthropists of all sorts have combined to administer the biggest doses that the often too willing victim could be persuaded to swallow, with lamentable results. In India and Burma there are still several remote corners where the inaccessibility of the country or the intractability of its inhabitants has left islands of primitive culture almost untouched by the surrounding waves of progress, and it must for long remain a problem to administer these areas in such a manner that the touch of civilization shall not destroy their inhabitants as the brass pot in the fable destroyed the earthen pot that swam with

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[1] Sollas, *Ancient Hunters*, p. 579.

it on the flood. It is here that anthropology has her part and I propose to indicate briefly a few of the ways in which she serves this end.

Now the first necessity for any man in dealing with a race of so-called "primitive" culture is to understand its point of view, and such an understanding depends on a particular sense of sympathy, by which I do not mean the feeling of compassion experienced by the philanthropist for the 'under dog' or by one of those, who have found salvation, for the unregenerate. That sort of sympathy sometimes does even more harm than good. But I mean the attitude of a man who can divest himself entirely of his own outlook on life, who can ignore the values which he himself places on the things of this world and of the next, and who can regard everything from the point of view of the members of the other race as they exist for themselves in their own scheme of life. A sympathy of this sort presupposes an intimate knowledge of the general conditions to meet which that scheme of life has through untold generations been built up; of the details of the scheme itself, and of the conduct of the individual within that scheme. But it requires more than that. It requires ability to appraise (not excluding the appraiser himself and all his works) from the point of view of one living in the scheme referred to, and with reference to the details of that scheme alone, thus giving values often entirely at variance with those which the sympathizer feels, in the light of his own society and of the circumstances of his own life, to be the values satisfactory to himself. He must be able, in fact, to think at will in terms of thought and value entirely other than his own. It may be that this goal is never wholly attainable, but any progress that is to be made towards it is facilitated in an almost unbelievable degree by familiarity with the science of anthropology.

I have in mind an instance in which an official who was sitting to interview some unsophisticated villagers was angry because they squatted before him instead of standing in his presence, but as a matter of fact no disrespect was intended. On the contrary it would have been highly disrespectful for them to have elevated their less worthy heads above his head, the sacred part of his person, the seat of his soul. This, of course, he did not know, but had he cared to know, both sides would have understood each other and gained accordingly. And I would here reiterate that to the anthropologist all customs are natural, and even head-hunting, human sacrifice, and cannibalism, however necessary it may be to suppress them, are not revolting and atrocious crimes, but reasonable and inevitable acts resulting from beliefs and ideas logically applied to circumstances and environment. Seen in this light, measures taken to put an end to them are much more likely to be humane and effectual than mere prohibitions and punishments enforced

on people who know perfectly well that their point of view is unappreciated, unconsidered and ignored. People in this frame of mind cannot appreciate the motives which lead to interference with their customs, and will distrust accordingly those who interfere. Probably all the rebellions which have taken place in Assam, for instance, since its occupation by the British have taken place as a result of ignorance or misunderstanding both of their rulers by the ruled and of the ruled by their rulers. I do not suggest for a moment that this particular ignorance or misunderstanding could have been avoided, but merely that any knowledge which tends to prevent or to remove its existence is of great administrative value. But while mutual ignorance may sometimes lead to rebellion or disturbance, it must in the end lead to apathy, depression and degeneracy, and I suggest that this is one reason why so many primitive tribes decay under administration. Even in Assam, where, in general, the hill tribes have been well looked after, such decay is frequently apparent. Thus the Mikirs are related to have been once a virile and warlike race, but to have been deprived of their arms by the Ahoms. The rather wretched opium eaters who are their descendants show little signs of ever having been a power in the land. The Khamtis, when we first came into contact with them, were a vigorous, martial and energetic race, but they are now described as "inconspicuous and opium sodden."

I have taken sympathy, in an anthropological sense as the first necessity in the administration of wild men, but there are a number of ways in which an anthropologist's knowledge of custom enters directly into the daily life of administration, and the most obvious of these is in the administration of justice. An application of intricate codes of law and elaborate juridical systems with their delays, their formalities and their nice distinctions is probably necessary in civilized life, but it is likely to operate very hardly upon a primitive community, to cause much injustice and to give little satisfaction to anyone. In the first place such communities, though often following intricate and difficult customary rules, have, generally speaking, entirely different standards from those to which we are ourselves accustomed. Torts, for instance, are everywhere recognized, but crime, as such, hardly at all. If it is recognized, it is in the breach of some tabut likely to bring disaster on the community, and punished by some sort of action taken to avert that disaster, whether by sacrifices at the expense of the offender, or by his expulsion from the community in order that the latter may escape the consequences of his act. Thus in a case which recently came into my court, a man whose small daughter had committed some fault, probably not for the first time, proceeded to frighten her into good behaviour by tying her up and putting her on the swinging

shelf that hangs over every Naga hearth to prevent sparks rising to the thatched roof and to receive meat and fish placed on it to be smoke-dried. When his wife's mother interfered to release the child, he struck her. Being a man of more than usual truculence, he refused to pay the compensation assessed by the village headmen, who brought him to me. I dealt with the case as between the man and his mother-in-law's relatives, and then asked the headmen what ought to be done to a man who thus ill-treated his daughter; what was the village custom? The answer was "Nothing." The daughter was his own. If anything happened to her the loss was his; who would have cause to complain? If Government regarded his action as an offence to be punished, let Government see to it; it was nothing to do with them. I therefore saw to it, but the offender and his friends considered that he was treated with injustice on account of the mild punishment accorded. On the other hand, in cases of homicide even if accidental the culprit is banished from the village, probably because his presence is likely to entail a serious blood-feud and more killings, and so to disturb and weaken the community. Offences such as incest, through regarded with aversion and even horror, are allowed by most tribes to go unpunished by man.

Detailed knowledge of custom is often of great value, as when guilty intention was proved in a case of homicide by the precise manner in which the killer subsequently washed his hands, but acquaintance with beliefs and ideas, which are usually unexpressed in words, and are often unexpressible in words in languages lacking in any means of conveying an abstraction, is much more valuable still. This is particularly the case in dealing with the obscure and rather indefinite workings of the mind obsessed by witchcraft. Often the magistrate or judge has to reckon with the fact that the person accused of witchcraft genuinely believes in his or her own powers, even if they are exercised involuntarily, as in the case of a woman who admitted to me that it was quite true that a child had died merely because she had handled it. How could she help it, she said; there was no ill intention on her part, but she had the misfortune to have a poisonous hand. Which being so, of course, she had no business at all to touch anyone so susceptible to evil influences as a small child, and knew it.

In anything of this nature belief has obviously a very important influence over the actions of primitives, but they are so incoherent and obscure when it comes to trying to put that belief into language, that it is often only the knowledge of what the mental process is likely to be that makes it possible to follow the thought and to deal with the case in a manner which is at least comprehensible and may with luck be satisfactory to the people concerned. And it is in cases of this sort that it is probably hardest of all to give satisfaction. It would

never be regarded as just merely to dismiss accusations of witchcraft as mere superstition, nor would it do anything to solve the difficulty which has led to the complaint in court. Those accused of witchcraft do believe, in many cases, that they possess supernatural powers, and in all cases that if they do not themselves, others do. They therefore consider perfectly just forms of procedure and punishments which appear to us unreasonable and iniquitous, or at any rate inequitable, but to which they are surely entitled as long as their point of view remains unchanged. All sorts of other similar cases occur. For instance, an old Sema, who had come to the conclusion that his bad health was caused by the absence of his soul from his body, a frequent cause of illness according to Semas, went down to the fields where he thought he might have lost it, killed a chicken for it, and called it. He went home, calling to his soul, by his own name, of course, from time to time to make sure that it was following. A personal enemy, aware of what he was doing, took a stick and hid by the path. As the old man went by, calling over his shoulder to the invisible soul, his enemy leaped out of the grass suddenly and brought his stick down with a thwack on the ground just behind the old man's heels. The timid soul was frightened and fled, and the old man died on the third day, and his relatives rightly accused his enemy of murder. Now this business of calling back the soul may appear to us to be farrago of foolishness, but it is very real indeed to those that believe in it, and though it may be said that what actually killed the old man was the unaccustomed effort of going down to the fields and climbing back again, it is equally likely that he died as the result of auto-suggestion, thinking that he could never more recover his soul, which was scared away for good. That, at any rate, is what all the Semas concerned thought, and it may be taken as certain that even if it was not the sole cause, this idea largely contributed to his death. The enemy got off, as he denied the act entirely and on oath, and there was no evidence beyond the dead man's statement to his friends, but had there been enough evidence he would probably have been convicted under the penal code, and rightly convicted, of causing death, and his fellow villagers would have held this to be entirely just and proper.

Nor is it merely judicially that anthropological knowledge is useful. It was recently suggested to me that some system of memory training was urgently required in primary schools in the Naga Hills district. This, on the face of it, might sound absurd, as generally speaking the Naga has an amazing memory, and an interpreter can take out, say, thirty processes on a fortnight's trip and serve them all correctly, explaining the wherefore of each, without being able to read one of them. But it is well known to anthropologists that the acquisition of a knowledge of reading and writing is only too apt to kill out all folk-memory

and that traditional lore which is handed on from generation to generation by word of mouth, and to kill it out so quickly that it is lost before it can be recorded.

But the greatest importance of anthropology to administrators is in informing them and warning them of the evil effects which follow universally the contact between a lower and a higher culture. Much information has now been amassed, which makes it more possible to gauge the probable results of impact generally, and both the immediate and remoter effects of measures taken. That it is necessary to take action, and that the old policy of *laissez faire* will not do, has been brought out very emphatically at the recent meeting of the British Association at Oxford. The Revd. Edwin Smith, speaking on this subject in regard to Africa, stated that the decrease in population in French Equatorial Africa as a result of contact with civilization was three millions in fifteen years, and that in most of East Africa the deaths exceeded the births in spite of the abolition of intertribal warfare, human sacrifice and the smelling out of witches, and Dr. Schwitz, a leading Belgian authority, put European civilization in the forefront of the causes of African depopulation.[1] Captain Pitt-Rivers had also much to say on similar results of racial contacts both in the Pacific and in Africa. The problem inevitably varies according to local conditions, but general lines of action can be determined with reference to the science of anthropology, and no administration has the right to bilk the question.

No less a responsibility lies with missionaries. Captain Pitt-Rivers has recently described their activities as "an irrelevant hobby," and there is this much to be said for his view, that their work, from its very nature, is fraught with the peril of doing more harm than good. *Non mores sine legibus*, perhaps, but *non leges sine moribus* for certain. For the generality of men morality depends for its sanction on religion, so that religion is the cement of society. When that cement crumbles and is loosened, the danger is that the whole building may collapse. This is what is to be feared from any proselytism which ignores the dangers with which it is involved. "If we treat as contemptible," says Frobenius,[2] "what to another is sacred, we ruin him," and this has too often proved to be true. Thus Professor Smith, himself at one time a missionary, writes of the Ao Nagas "Boys in Christian families are refusing to serve at the young men's house. This was an important educational institution for boys. There were regular ranks through which the boys passed until they attained to adulthood and were admitted to full membership. Each order had to

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[1] *The Times*, Aug. 6th, 1926. Report on the proceedings of the British Association (p. 8).

[2] *Childhood of Man.*

perform some distinctive service for the men who belonged in the bachelors' house. The break from this destroys a valuable disciplinary agency, and causes the boys to lose respect for the authority of their elders."[1] So, again, the Census Report for Assam of 1921 says that Ao girls educated by missionaries neglect work in the fields, for which their newly-adopted long skirts are quite unsuitable, and idle in the village instead. So, too, Mr. J. P. Mills says of "civilized" Nagas that they "almost invariably become parasitic on the community, and are content to wait for suitable appointments entailing no manual labour." The model to which the Naga is being assimilated is a civilized type that in Naga surroundings "must either be fed by others or perish," and it is this type of civilized Naga that the missions tend to produce.[2] "The mere fact," writes Cooley, "of discrediting noted beliefs and habits, in order to substitute something unfamiliar, is almost inevitably destructive. Many individuals may be really Christianized.....while at the same time the overthrow of the native institutions is causing another class, possibly much larger, to become irresponsible and dissolute."[3] So serious is this danger, that the Royal Anthropological Institute has formed a special committee with the purpose of allying missionaries and anthropologists in the investigation of the means by which the evil effects of racial contact may be studied, counteracted and avoided.

I do not therefore suggest that missions cannot play a useful part in aiding the accommodation of primitive tribes to fresh contacts but I do suggest, from my own experience, that they are apt to destroy more than they create, and in so far as they do that, they do more harm than good.[4] Man, at any rate the average man, cannot live by religion alone. In the case of the Naga a very important part is played in village life by feasts and dances. These are not essentially religious, though, as into the festal life of any civilized community, religion inevitably does enter. It is to these occasions that all the village looks forward for a break in the monotony of life, for an opportunity to give free rein to the artistic senses, whether in colour, or in motion, or in song. The gala dress of almost any wild Naga shows an admirable taste expressed in white and scarlet and black in a most pleasing accord with the reddish skin that wears it. An Angami festival is a feast of gorgeous and harmonious colouring, and in some tribes the dancing is of a very high standard indeed. Yet of these only singing, in the

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[1] Smith, *Ao Naga Tribe of Assam*, p. 193. More to the same effect will be found in Mr. J. P. Mills' *The Ao Nagas*, recently published.

[2] *Man in India*, III, 222.

[3] *The Social Process*, p. 189. Quoted by Smith, *op. cit.*, p. 208.

[4] Cf. Buxton, *Depopulation of the New Hebrides*, in Transactions of the Royal Society of Tropical Medicine and Hygiene, vol. XIX (1925-26), p. 453.

form of hymns, is allowed to survive conversion to Christianity. Bright clothes and gay dances are heathenish and therefore tabu. The Lhota Christian may wear only plain cloths, and a sanctimonious countenance; laughter savours of pagan levity.[1] This is assuredly all wrong. I can see no reason (but I speak as a heathen) why a sense of colour and a sense of rhythm, no less than a sense of song, should not redound to the glory of God who gave them. And I suggest that to deprive simple men of their use in the name of religion is a sin. Not thus did the fathers of the ancient Church, who incorporated the heathen feasts of Europe into the Christian calendar as Easter, Whitsuntide, St. John's Day, Michaelmas, Hallowmas, Christmas and many others. If there is one thing more than another which suggests that there is something wrong with Christianity as practised and preached to-day, it is its apparent inability to shed the incidentals and, while retaining the essentials, to adapt itself to the life and needs of those to whom it is newly preached. I should be sorry, however, to suggest that missionaries alone adopt this attitude. The Commissioner for Indian Affairs in the United States of America has forbidden dancing by the Indians of that country. He apparently considers that valuable time is given to dancing that might be devoted to industry and that it encourages a religious disposition, which induces an uneconomic generosity in the individual. Could any materialism be grosser?

To turn from the moral effects of contact to the purely physical side, the apparent rapid deterioration of physique on the part of a primitive tribe is often remarkable. The Nagas living on the south borders of the Lakhimpur District of Assam probably afford as good an example of this as any, but occasional observers in the Naga Hills district, in particular I may mention the name of Mr. Henry Balfour, have commented on the fact that the independent Nagas across the frontier are of finer physique than those of the administered district. Mr. Balfour went further and said that it struck him that the Nagas of the more recently administered parts ware again finer in physique than the inhabitants of areas long taken over.[2] If this is so it is a serious reflection on the evil effects of administration, and a short enquiry into the facts and their causes may perhaps not be out of place. The question is complicated by the varying physique and appearance of tribes which naturally differ as a result of racial composition, and by the inevitable climatic effects of different habitats. Thus the Lhota, living in the lower and hotter ranges near the plains, is likely to be of poorer

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[1] See J. P. Mills, *The Lhota Nagas*, p. xii, and *The Ao Nagas*, p. 415; *cf.* also Brewster, *Hill Tribes of Fiji*, p. 66, and Buxton *loc. cit.*, p. 432.

[2] Presidential Address to the Folk-lore Society, *Folk-lore*, March, 1923, p. 21.

physique than the tribes living in the high hills, and the Ao living inside the frontier is of inferior physique to the Chang living alongside him but just across it, owing probably to racial difference, the Ao appearing to be of superior physique to the Phom, also his transfrontier neighbour and the neighbour of the Chang as well. On the other hand, the administered Semas are unquestionably, I think, of poorer physique on the whole than those across the frontier, and Angamis of the village of Khonoma once told me that they have deteriorated in stature and stamina since being administered. Generally speaking however, I doubt if the Angami tribe, now all administered, has suffered much in that way. The deterioration in Khonoma has probably been due partly to distilling and consequent drunkenness in the village and partly to the importation of malaria and other diseases by traders, as Khonoma has replaced raiding and war as the primary interest in life by long trading expeditions, men of that village visiting Calcutta and even Karachi and Madras to buy beads and wandering all over Burma to sell them. This practice (as that of distilling) is of course, consequent on administration, but supplies a badly needed outlet for the energies formerly spent on war. In most Angami villages the practice of intensive cultivation and the preservation un-impaired of village festivals and feasts for the acquisition of social status by individuals seem to have been successful in maintaining the interests in life which is necessary if the tribe is not to deteriorate. In addition to which the Angami is conscious of not being dependent on administration for his survival, whereas the Ao and to some extent all the neighbours of the Angami, except perhaps the Sema, tend to regard Government as a source of protection. The Angami on the other hand, as also the Konyak in the north, are probably still inclined to regard the British Government as a temporary evil which will pass in due season, and the Angami, like the Konyak again, is far more conservative than the other tribes and much less receptive of new beliefs, the fact being that he has confidence in his own view of the nature of things and has not yet had that view undermined and exploded. His real religion is rather ancestor-worship than anything else and it is not nearly so easily undermined as are the vague beliefs of other tribes already shattered by migrations and invasions among themselves. The Angami in fact has been able to retain his belief that he is a better fellow than anyone else at all; and his excellent system of cultivation has prevented his suffering like the Sema from scarcity of food. The Tengima Angami probably thinks that if he could only get hold of suitable weapons he could drive the sahibs out of his country—and long may he continue to think so, for there is nothing so stimulating as a good opinion of oneself. To return to the case of the Semas, a tribe whose country is overpopulated and whose food supply is

always on the scarcity margin, the effect of administration has been to restrict expansion at the cost of less warlike tribes and thus to cause inevitable deterioration as a result of shortage of land and an inadequate food supply. The tribes across the frontier have naturally suffered less, and until quite recently, at any rate, the transfrontier Semas have been expanding at the expense of their neighbours.

As regards all the administered tribes the prevention of head-hunting and war have of course had a detrimental effect in some ways. Across the frontier there is more competition and a harder life; more need for vigilance, resource and address. Personal efficiency is the primary standard and wealth secondary, whereas under administration wealth stands first and the tribe suffers by the change. Also it is true that across the frontier the hills are higher and colder and the land inhospi table, and it takes a tougher digestion to live on *coix lachryma* than on rice. Still, I think, the vital factor is that under the conditions obtaining before administration it is necessary for everyone to live on the alert, a state of things undoubtedly contributing to active habits of mind and body, while under administration the partial loss of these habits is inevitable. But there are other effects which can be checked if not prevented. Perhaps the most important of these is the spread of disease. Under the old conditions in the Naga Hills many diseases now common appear to have been practically unknown, and it is safe to say that one of the first effects of administration is to spread epidemics which cause far more loss of life in a short time than head-hunting ever did in a long one. Smallpox, measles, influenza and syphilis are probably all new diseases in these hills. Tuberculosis which seems to have been unknown 20 years ago is now common. I remember, a medical missionary telling me 14 years ago that in his experience there was practically no tuberculosis in this district. A few years later he commented on having had to treat several cases, and now the disease is of comparatively common occurrence. Two at any rate of my interpreters have died of it in recent years.

As in Melanesia the introduction of European clothing and its misuse are probably responsible for a certain amount of disease. We read of Melanesia that decrease in population is in progress since the administration of the white man owing to changed conditions of life, among which preference is given "to the injudicious use of unsuitable clothing, which . . . is a fruitful cause of disease and the introduction of new diseases."[1] I think there is a very serious danger of a similar result in the Naga Hills; and probably the process is already actually in operation.

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[1] Woodford in *Depopulation of Melanesia*, p. 69, and Buxton, *loc. cit.*, p. 437.

So, too, a change in the method of building houses, leading to the adoption of a type new to the environment, may be dangerous. It has been pointed out that in the Cook Islands the indigenous type of house is ventilated throughout as a result of its method of construction, and overcrowding is immaterial. People sleep as many as a dozen together in a small room shut up at night for fear of ghosts. When, however, this practice is followed in the wooden houses built on lines taught by missionaries, it results in a very unhealthy atmosphere indeed, and the practice immediately becomes favourable to the spread of disease.[1]

Another cause of the decline of population in certain localities of the district is probably to be found in an undue amount of compulsory load carrying. Of course without a certain amount of such carrying work the administration of the district could not be carried on, and it is necessary to call villages to supply carriers, but it will be found that in the hot climate of the lower hills, where work of all kinds is much more trying than in the high ranges, there is noticeable decay in the population of all villages lying near a Government road. That this is not merely due to the climate is suggested by the fact that such decay is much less noticeable in villages further from such routes. Thus villages on the outer range such as Kansing Toluba, Aonokpo, Yamho Yantha, Yamho seem to have suffered considerably less from loss of population than villages actually on the road like Changchang, Lakhuni, Bhandari and Yimbarasa. So too in the Angami country the villages on the original route to the plains are much decayed, though this may be due to disease imported by strangers after the opening of a cart track as well as to too much carrying before that. I believe there is a similar scarcity of population along the Manipur-Cachar bridle path. That this decay really is due to excessive exertion is suggested by the extraordinarily high death-rate among the Lhota coolies who went to France with the Labour Corps or who carried loads during the Kuki Operations in 1918-19. A noticeable point about the Lhota coolies who were found to have died, when their belated medals come to be issued, was that although most had married very few left children. Apparently their fertility had been effected by the strain they had undergone.

An entirely unexpected result followed the introduction of monogamy in the New Hebrides. Instead of reducing, as might have been expected, the extent of the practice of abortion, it increased it, as husbands of one wife found that pregnancy caused an inconvenient interference with the daily routine,

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[1] McKenzie, *Observations on Filariasis, Yaws, etc., in the Cook Islands.* Transactions of the Royal Society of Tropical Medicine and Hygiene, vol. XIX (1925-26), p. 139.

which was not experienced in the former polygamous households, and abortion was more freely resorted to in consequence.[1]

I have referred to one or two aspects of the contact question in the area with which I am familiar as examples. There the most important need appears to me to be to control the contact between civilisation and the wild tribes, so that progress is very slow and that the wild man may have time to accommodate himself gradually to new conditions. The great danger is in introducing change too fast.

It is considerations of this sort that will cause serious misgivings in the minds of many anthropologists at such news as that of the simultaneous release of all slaves in the Hukong Valley by money payments. Such a proceeding must inevitably disturb the whole of the economic and social life of the people affected. The system of slavery in that part of the world is, generally speaking, a very mild one, and it could surely have been put an end to gradually by prohibiting transfers of ownership, redeeming all children in the present and for the future, or by some similar method which would have allowed the change to take place gradually. It would have given a chance to the people affected to accommodate themselves to the new conditions of life in a way that must be denied them by a sudden and sweeping change. Cash is no substitute for labour in the wilds; it is no substitute for crops, and where there are no banks or investments it may soon be spent. To effect the change gradually would probably have been cheaper, and would certainly have been more humane, but of course it would not have been spectacular.

However, different areas will have their differing problems and there is no one remedy for all, but I think that many of you will agree with me that the present position is unsatisfactory and could be much improved. Among other things much greater freedom is needed in regulating the communications between primitive tribes and the more civilised world. Enlightened countries like Australia have gone so far as to prohibit the entry of any persons whatsoever into their native reserve except occasional scientists and the administrator of the tribe. Even schools and missions have been barred, as this appears the only way at present of protecting the remnant of their aborigines from extermination. There is no reason why legislation on somewhat similar lines should not be applied to these primitive areas of India and Burma, and it would vastly improve the present position with regard to the acculturation of aborigines if the entry of civilized foreigners and of their trade goods into such areas was put under very much severer control than it is at present. As I have said before civilisation is a drug and its consumption needs very careful regulation and

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[1] Buxton, *loc. cit*, p. 425.

supervision. Primitive man is perfectly capable of a gradual accommodation to changes, which will kill him if introduced suddenly, and it is probably wrong that he should be killed. At any rate it is inimical to the acquisition of knowledge. Another measure that I would advocate would be to make examinations in anthropology—Physical, Social and Cultural—carrying effective marks—compulsory for entrance to all the public services on which the administration depends. Anthropologists know that haste in civilising, educating, and acculturating is likely to do more harm than good. The difficulty is that other people do not believe it. The facts are at variance with political and philanthropic tradition, and therefore unwelcome. It is not an easy thing to induce a large number of persons to discard the familiar and comfortable ideas of a lifetime in reluctant exchange for new and unaccustomed views, but it is our duty to keep trying even though we feel, as I so often do myself, like a sparrow disconsolate on the house top or a voice crying in the wilderness.

Abstracts of Papers.

1. The Bull Roarer in India.

Rai Bahadur Sarat Chandra Roy, Ranchi.

A few forms of "Bull roarers" met with in India, specimens of which I have collected and which I intend exhibiting to the audience, and mention what uses are made of them now.

2. On a peculiar fishing implement from the Kangra Valley.

Dr. S. L. Hora, Calcutta.

During his recent tour (May-June, 1926) to the Kangra Valley the author noticed an interesting type of fishing implement, locally known as *Kalerni*. The implement consists of three pieces of hemp twine knotted together and a number of horse-hair nooses tied to the central piece, the two end pieces of twine being knotted so as to form running nooses.

Kalerni is modelled after similar devices used for snaring birds all over India, Burma and the adjacent countries. It is used in very rapid waters of our shallow and rocky streams for catching small fishes of the genera *Garra*, *Glyptothorax*, *Nemachilus*, etc.

In using this ingenious device advantage is taken of the habits of the hill-stream fishes, which are either migratory or are provided with suckers and frictional devices for sticking to rocks and stones in swift currents.

3. Some objects of Anthropology.

J. P. Mills, Calcutta.

The value of Anthropology is often doubted. We must be able to answer our critics. Anthropology arises from the natural desire of human beings to study themselves. The scope of each of its main divisions—Physical, Psychological, Archæological and Social—is outlined. Each is linked with other branches of knowledge, and Anthropology is shown to concern itself with all the sciences as they converge on man. This is one of its most valuable characteristics. Critics who scorn all knowledge which has no immediate utilitarian value are wrong. All knowledge is valuable, and Anthropology is especially valuable now. The culture contact of ancient times has become a world-wide culture clash. Primitive races are being irreparably harmed not only by the trader but by the would-be reformer. The ruthless sweeping away of ancient culture is harmful. The deliberate efforts of American Protestant Missions to impose a uniform culture everywhere are revealed by their own writings. In a few places imported culture is still resisted, but this cannot last for ever. Anthropologists have a great work before them in guiding and easing the inevitable culture clash.

4. Sectarian marks of Hindus in South India.

Rai Bahadur L. K. Ananthakrishna Iyer, Calcutta.

Introduction—Various sect marks—Their significance—Mystic influence involved in them—Conclusion.

5. Totemism in South India, with special reference to Mysore.

Rai Bahadur L. K. Ananthakrishna Iyer, Calcutta.

Introduction—Totemistic castes—Survivals of totemistic beliefs—Comparison of similar beliefs in other parts of India and in other parts of the world.

6. Polyandry in the Mahabharata

H. C. Das-Gupta, Calcutta.

The polyandrous form of marriage between the Pandava brothers and Draupadi is a very important episode in the great epic of Mahabharata. The generally accepted view regarding the marriage is that it was purely accidental. The matter is thoroughly discussed and reasons are given for maintaining that the marriage was a deliberate one and not accidental.

7. Untouchables among animals and plants.

Rai Bahadur Hiralal, Jubbulpur.

Synopsis : A Hindu extends his idea of caste to animals and plants also and assigns untouchability to some of them as he does in the case of certain Sudras. Illustrations from the Central Provinces are quoted and further ones from other provinces invited.

8. The Tortoise in Indian life and religion.

S. T. Moses, Calicut.

Legendary : Tortoise in Hindu cosmogony—Prajapathi as Kurma the creator—Vishnu as Kurma in the churning of the ocean.

Deities : At 'Sri Kurmam' in Ganjam and at Nerenika in Bellary.

Religious ceremonies : Burial of live tortoise under the altar—Use of Kurmasana.

Tortoises as sacred pets : In the Jumna at Agra—In ponds of pagodas in Burma—In tank attached to the temple of Jagannath at Puri.

Tortoise taboo as food : Among east coast fishermen, also in Maldives and Laccadives—on the west coast catching it is a sin but not eating.

Tortoises and houses : Nayar house sites—The Silpa Sastram—Unlucky to enter houses.

Totems : Oraons—Adidravidas—Patnavars and Shedans.

Tortoises in stories and proverbs : Panchathanthra—Tamil Proverbs—Malayalam Proverbs.

9. The sanctity of hair in South India.

S. T. Moses, Calicut.

Barbers' importance in Hindu Society—Fashion of wearing one's hair an index to his caste, religion or district—The tuft and its significance—The Nazarite custom among Christians—The first shaving ceremony among Hindus—Shaving when taboo—Hairclippings and magic—Hair and exorcising demons—Why demons have an aversion to hair—An 'Evil eye' custom among Muhammadans—Offerings of hair to God—Tonsure of widows—Dropping shaven hair into Thriveni at Allahabad—Hair in lockets as tokens of affection or memory—The hair 'tali' among Maravas—Hair relics of Buddha and Muhammad as objects of reverence—Mohammad's hair relics in Delhi, Bijapur, Rohri (Sind) and Elimala (Malabar).

10. The Calendar of the Angami Nagas.

J. E. Tanquist, Assam.

1. The Moon is the chief time measurer.
2. Each month has a special name.

I. The interpretation of names of months :
   1. The Angami months.
   2. Reference to interpretations recorded of a few other groups.
   3. The Thado Kuki months.
   4. The Tankhul months.
   5. The Rengma months.
   6. No description on record for the Ao months; probable reasons.
   7. The term "descriptive moon series."

II. The insertion of the intercalary month :
   1. The problem seems a bit intricate.
   2. The solution is in practice simple.
   3. But there are some difficulties involved.

III. The solstitial reckoning :
   1. This is known to certain Angamis.
   2. It is only of secondary importance.
   3. The people will not give up the descriptive moon system of reckoning for a good while to come.

11. On the cult of Gorakshanātha in the district of Rangpur in Northern Bengal.

S. C. Mitra, Calcutta.

In this paper Prof. Mitra has shown that the godling Gorakshanātha is a deification of the famous ascetic of that name, who was born at Gorakshpur in U.P., and that this deity's reputation as guardian-spirit of milch-cattle has been derived from the fact that his antetype Gorakshanatha of Gorakshpur was the son of a pious cowherd and, as such must have had great affection for, and solicitude for the welfare of, cattle in general.

Mr. Mitra has further shown that this godling is worshipped in the district of Rangpur in Northern Bengal. Whenever cattle fall ill, the owners thereof set up a *ghata* or earthen pitcher to represent his deityship and worship him by the recitation of *mantras* or prayer formulae and by the presentation to his deityship of food offerings. Sometimes no *ghata* is set up to represent his deityship or no other kind of image is made of him. The worshippers simply contemplate the deity and present to him an offering of thickened milk or of balls made of clotted cream, as milk is the most valuable product of the cow, whose welfare is looked after by his deityship. Mr. Mitra thinks that in this district the cult of Gorakshanātha has degenerated into an Animistic or Fetish worship.

Mr. Mitra further thinks, that in former times there was, and there is even at the present day, considerable intercourse between the people of the United Provinces of Agra and Oudh and those of Northern Bengal by way of North Behar, Purnea and Malda and that immigrants from the U.P. must have introduced the cult of Gorakshanātha into Rangpur.

12. A Rangpuri superstition.

S. C. Mitra, Calcutta.

In the district of Rangpur in Northern Bengal, a superstition prevails to the effect that *bamboos should not be cut on Sundays.* In this paper, Mr. Mitra has shown that, in that district, as also in the adjoining district of Dinajpur, bamboos are worshipped once every year, especially during

the spring season. They are worshipped as symbols of the aboriginal animistic godling *Madanakāma*, which presides over generation. He further thinks that Sundays must have been especially consecrated to the worship of this godling. From this has arisen the prohibition against the cutting on Sundays of the sacred bamboo, which is the symbol of that deity. In the remotest times Rangpur and Dinajpur must have been covered with primeval tree-forests and bamboo-groves and the aboriginal Rajabanshis, who dwelt therein, believed those trees and bamboos to be the dwelling-places of ghostly crew of unseen and incorporeal beings, whom we now call animistic deities. These animistic deities were believed to be capable of doing good or harm to them. It is for this reason that the aboriginal Rajabanshis worshipped the bamboos or in other words, propitiated the animistic spirits dwelling in the bamboos with the presentation of offerings.

13. Note on the use of ferns as an article of food in the district of Rangpur in Northern Bengal.

S. C. Mitra, Calcutta.

In this paper Mr. Mitra states that the lower classes of the people of the district of Rangpur, in Northern Bengal, partake of the tender leaves of many kinds of plants in their curries. The leaves of the jute-plant are much used for this purpose. A paste made of the leaves of the jute-plant is made into an eatable which is called the "*pelka.*" The most curious leaf which is partaken of by the people of Rangpur is the frond of the 'Edible fern' (*Asplenium esculentum*) as a pot-herb. It is noteworthy that several members of the genus *Asplenium* grow in England but are not eaten by the lower classes of the English people.

14. Note on the legends about the origin of the place-name Rangpur.

S. C. Mitra, Calcutta.

In this paper Mr. S. C. Mitra has discussed the three legends, which are usually narrated about the origin of the place-name Rangpur in Northern Bengal. The first of these legends sets forth that this name has been derived from the fact that Bhagadatta, Rājā of Kāmrup, had a palace of pleasure or *Ranga-pura* at the locality where the modern town of Rangpur stands. But no traces of this palace are to be seen at the present day. Nor is the name Rangpur to be found in the Mahābhārata or in any other work of Sanskrit literature, nor in Blaeu's Map of the Moghul Empire (published in 1645 A.D.), nor in any Muhammadan history-book earlier than the "*Riyazu-a-Salatun,*" which was published about the end of the 18th century A.D. The name Rangpur appears for the first time in this last-mentioned work. Mr. Mitra therefore rejects this legend as totally unworthy of credence. He has also rejected, on the ground of its being a childish and silly fabrication, the second legend which sets forth that the name has been derived from the fact that a Raja of Rangpur, when requested by the Raja of Benares to give a description of the former's country, gave a jocular description (*Ranga* or jest) of it.

The third legend or tradition is to the effect that this place-name has been derived from the dyeing industry of the district, as the word "*Rang*" means dye or colour. Mr. Mitra thinks that this legend is a near approximation to the truth and suggests that this place-name is very likely a contraction of the Persian word "*Rangrezpur*" or the place of abode of the dyers, with which the officers of the Moghul Government must have dubbed the place.

15. A Satya Pīr legend in Santali guise.

S. C. Mitra, Calcutta.

In this paper Prof. Mitra deals with and discusses two legends about the Mussalmān saint *Satya Pīr*, and an analogous Santali folktale, of which the story-radical has been formulated by him as follows :—

(1) Two or more persons, all of whom were married, had a youngest brother who was unmarried. (2) The wives of the elder brothers were all witches and bore a grudge against their youngest brother-in-law. In order to feed fat their grudge they administered a magic potion to the latter or cast spells upon him. By drinking the potion or under the influence of the spells he was changed into a bird or a dog. (3) By the blessing of the supernatural being he married a princess, who was able to remove the evil influence of the charms and to restore her husband, who was disguised under the form of a bird or a dog, into his former human shape. (4) Subsequently the youngest brother informed his elder brothers of the fact that their wives were witches and had, by means of their enchantments, changed him into a bird or a dog. On hearing this, they were exceedingly angry with their wives, whom they subsequently killed by way of punishment.

As the foregoing story-radical does not come within the category of the *seventy* (70) *types* of folktales studied and classified by the Folk-Lore Society of London, Mr. Mitra is of opinion that it is an altogether new one. He has therefore named it "*The bewitched youngest brother type.*"

Then as regards the question as to how the *Satya-Pīr Legend* found its way among the Santals, Mr. Mitra thinks that as Western Bengal is conterminous with the Santal Pargana, which is the home of the Pre-Dravidian Santals, the Santals borrowed the legend from the Bengalees and assimilated it as their own, making sundry changes to suit their local conditions.

16. Further note on human sacrifice among the Santals.

S. C. Mitra, Calcutta.

In a previous paper, Mr. S. C. Mitra has shown that formerly the Santals used to offer human sacrifices to (i) *water-deities* and (ii) to *earth-deities.* In the former case, whenever a tank was dug, and no water came out of it, the Santals ascribe the non-appearance of water to the wrath of the offended water-deity. They, therefore, propitiated him by drowning a human victim in the tank. They further believed that this sacrifice resulted in the tank filling up with water. In the second case, they used to kill a human victim and bury his corpse in the earth under the belief that the offended earth-deity would be propitiated thereby and would confer good luck upon the offerer of the sacrifice. In the present paper Mr. Mitra has further shown that they also used to offer human sacrifices to (iii) another class of supernatural beings or spirits whom they called "*Bongas.*"

17. Note on a recent instance of self-immolation for propitiating a god.

S. C. Mitra, Calcutta.

In this paper Mr. S. C. Mitra has described and discussed a case of *self-immolation* for propitiating the god Śiva, which occurred on the 26th August, 1926, in the famous temple of the afore-mentioned deity in the village named Chitora, Police-station Purulia, in Chota Nagpore. In this case a Maghaya Brahmin who was suffering from some distressing ailment, gave "*Dharna*" for several days together before the said deity

in the hope that his deityship would either appear before him in a vision or furnish him with some medicine for the cure of his malady. But the god did neither of these acts. He, therefore, cut his own throat *on the Siva-Linga* at dead of night.

Mr. Mitra thinks that this was a case of self-immolation committed by the patient under the belief that the deity had been exceedingly angry with him and that he required to be propitiated by the presentation to him of a very valuable offering. As life is God's most valuable gift to man, he sought to propitiate his offended deityship by offering him his own life.

18. The Indian folk-belief about the corpse's eating the winding-sheet in which it is swathed.

S. C. Mitra, Calcutta.

In this paper Prof. Mitra has described and discussed the origin of the under-mentioned folk-belief, which, in a more or less modified form is prevalent in Bengal, North Bihar and the Bombay Presidency :—

Whenever an epidemic rages at its highest, the corpse of one of the persons who have fallen a victim to it is swathed in a winding-sheet and, instead of being cremated, is buried in the earth in a standing position. This burial of a Hindu victim of the epidemic is popularly believed to put a stop to the fell disease which may be raging. If it is not stamped out or does not abate in the least, the people dig up the buried corpse and see whether it has *eaten* or *chewed* the winding-sheet, in which it has been swathed up. If it is found to have done so, it is looked upon as a bad omen, as it portends the further spread of the epidemic. In any case, however, the people cremate the disinterred corpse, in the belief, that it will put a stop to the epidemic altogether.

Mr. S. C. Mitra further says that as the uncultured folk's belief is that all diseases are caused by the entry into the human body of disease-demons, they have accordingly hit upon two methods of curing the ills that human flesh is heir to, namely, that of flogging out the disease-demon from the patient's body, and that of putting a stop to epidemics and other outbreaks of diseases by burying the corpse of a deceased person, into whose body the demon had entered.

He further thinks that the second expedient or remedy, which has been devised by the uncultured folk, is that epidemics and other outbreaks of diseases can be stopped by the interment in the earth of the corpse of a person into whose body the disease-demon has entered and who has therefore died of the ailment. This, he says, is the root cause of the aforementioned folk-belief which is prevalent in North Behar, Bengal, and the Bombay Presidency.

19. Notes on the three Bengali women's charms for stopping storms.

S. C. Mitra, Calcutta.

In this paper Prof. S. C. Mitra has described and discussed the origin of three charms which are used by the womenfolk of Eastern Bengal for the purpose of stopping storms. In the first of these charms, the storm-demon is sought to be expelled by telling him not to touch, that is to say, to blow upon a hut or a room in which the wife of his sister's son is staying. The origin of this charm is based upon the well-known taboo, widely prevalent throughout Bengal, which prohibits a woman to touch the body of the brother of her mother-in-law and forbids the latter even to step upon the former's shadow.

In the second charm, the womenfolk invoke the names of divinities and semi-divine personages under the belief that they would thereby

compel the latter to put in an appearance and, by the exercise of their divine power, to expel the storm-demon.

Sometimes the womenfolk hurl invectives at the storm-demon under the belief that the magical efficacy, which is ascribed by peoples in a low plane of culture to the *spoken word*, would cause the storm-demon to beat a hasty retreat.

In the third charm, the Bengali womenfolk place in the courtyard wooden plank-seats *upside down* under the belief that, if this is done, the storm would pass away. This is an instance of the rite whereby a luck may be changed and the ordinary course of event altered by reversing the natural order of things.

20. The Poo-Nonbu in Kongu Nad.

P. M. Somasundaram, Bangalore.

An account of a festival observed by virgins among the cultivating classes of the Coimbatore District, S. India, together with a translation of the folk-song sung on the occasion.

21. Some popular beliefs in the lunar periodicity in animals and plants.

P. M. Somasundaram, Bangalore.

An enumeration of some notions prevailing in S. India, regarding a supposed connection between the growth, etc., of some animals and plants and the cycle of the moon.

22. Naga medicine.

H. G. Dennehy, Assam.

The Nagas have four distinguishable methods of treating disease, viz. (1) Propitiation, (2) Exercise, (3) Care by certain food stuffs, (4) Surgery. Their surgical methods are crude, and in (3) no clear distinction is drawn between foods that have genuine medicinal qualities, and those which are purely magical in their effect. The Naga *materia medica* includes a number of unquestionably sound prescriptions, but it is difficult to say whether they have been reached deductively or empirically.

23. The *Kani* (Opium) *Puja* of the Mikirs of Assam.

H. G. Dennehy, Assam.

The *Kani puja* of the Mikirs is a sacrificial ceremony, at which opium is burnt with a view to obtaining from the smoke omens as to the prosperity of the coming agricultural year.

24. The frog marriage in Assam.

T. C. Saikia, Assam.

This ceremony originated in legends regarding Indra, the God of Heaven; and is celebrated as a rite to cause rain to fall.

25. Palæolithic evolution in India.

L. A. Cammiade, Madras.

There exists in India a series of palæolithic cultures that, broadly speaking, follow the same line of evolution as the European palæolithic cultures: Chellean, Acheulean, Mousterian, Magdalenian, Caspian and Tardenoisian.

26. A comparative study of the human crania excavated at Adittanallur.

BIRAJASANKAR GUHA, Calcutta.

A detailed study of the dozen more or less well preserved crania excavated by Mr. Rea at the 'prehistoric' burial site at Adittanallur in the Tinnevelly district in Madras and their comparison with the Bayana and Sialkot crania of Northern India and the Veddah crania of Ceylon. Conclusions regarding the early population of India.

27. The matrimonial institutions of the Syntengs.

BIRAJASANKAR GUHA, Calcutta.

A detailed account of the marriage ceremonies of the Syntengs of the Khasi Hills and their comparison with the Khasi ceremonies.

28. A comparative study of some measurements of the Hos.

A. N. CHATTERJEE, Calcutta.

Number of subjects 263. Measurements dealt with—stature; head-height; head-length, head-breadth; nasal length, nasal breadth; facial length, facial breadth; orbito-nasal diameter, orbito-nasal arch. Indices taken—cephalic, altitudinal, nasal, facial, orbito-nasal. A comparative statistical treatment of the measurements. Classifications according to the systems of Haddon and Dixon. Conclusions.

29. A statistical study of some measurements of the Varendra Brahmins of Bengal.

TARAK CHANDRA RAY CHAUDHURI, Calcutta.

Number of subjects 180—Measurements dealt with—stature, head-height, head-length, head-breadth, nasal length, nasal breadth; facial length, facial breadth, orbito-nasal diameter, orbito-nasal arch. Indices taken—cephalic, altitudinal, nasal, facial, orbito-nasal. A comparative statistical treatment of the measurements. General observations. Classification according to the systems of Haddon and Dixon—Conclusions.

30. Terms of relationship of the Hos of Seraikela.

TARAK CHANDRA DAS, Calcutta.

The materials for this paper were collected according to the genealogical method in March, 1925, during an excursion into the tract. An attempt is made here to build up the conditions which favoured the development of the particular type of terms of relationship prevalent among the Hos.

31. Social organization of the Hos of Seraikela.

TARAK CHANDRA DAS, Calcutta.

It purports to be a study of the social organization of the Hos of Seraikela. The materials were collected during an excursion in March, 1925.

32. Stone implements from the Seraikela State.

PANCHANAN MITRA, Calcutta.

A description of several new sites in the Seraikela State (Chhota Nagpur) from which several chipped stones of a mesolithic type were picked up during the Anthropological excursion in February, 1926.

33. Iron slags from the Seraikela State.

PANCHANAN MITRA, Calcutta.

Iron slag bearing sites in the Seraikela State testifying to a widespread primitive iron industry in those tracts now inhabited mainly by the Hos. In one place bits of iron slag were found about 6 ft. from top buried under a rocky debris on the side of a new cut path between the rocks.

34. Ho hut-designs.

PANCHANAN MITRA, Calcutta.

The Ho hut designs in red or yellow generally are very picturesque and neatly executed on mud walls by Ho women. There are zoomorph and phyllomorph designs strongly reminiscent, like Bushman drawings, of prehistoric art motifs of mesolithic times.

Section of Psychology.

President:—Lt.-Col. Owen A. R. Berkeley-Hill, M.A., M.D., (Oxon), I.M.S.

Presidential Address.

Ladies and Gentlemen,

I stand before you this afternoon to deliver my presidential address with no mixed emotions. My emotions are simple and easily comprehensible. First, I am deeply sensible to the honour you conferred on me in electing me your President. I regard your choice of a psychiatrist as evidence of the catholicity of the interests of the Indian Psychological Association for hitherto the post of President has been filled by an academic psychologist. I am further sensible to the fact that I am the first European to preside over the deliberations of this section and I regard this second departure from precedent as an indication that racial feeling can find no expression in an assembly whose sole concern is the maintenance of scientific tradition.

While searching in my mind during the past few months for subjects that seemed important for discussion in this address, many things crowded into the focus of my attention. I realised that while I must rely mainly upon psychiatry for the subject-matter of my address, I must at the same time keep well in mind the obligation to acknowledge the great debt that psychiatry owes to workers in other fields of mental functioning. Psychology has now come to denote more than that "science of mind" which began with theory and ended where it began—a subject of no practical utility, existing wearily in schools and universities and dead to the pulsating life outside. Psychology is now a living science whose concern is the internal as well as the external phenomena of mental life. Its dynamic aspects render it of practical value in many directions. From all sides calls for help reach this dynamic psychology, as the medical man, the lawyer, the minister of religion, the educationalist and the social worker begin to realise its numerous practical applications. In these circumstances, the subject that I have selected to discuss, namely, Mental Hygiene, is one which appeals to me as being of significance upon this occasion. Whether my choice has been a wise one I leave you to decide.

I think that most of us will agree that the last thirty-five years will be looked back upon in time to come as covering a period of psychological development that has no parallel in previous history. It was Emil Kraepelin (whose compara-

tively recent death has deprived us of the honour of welcoming him here to-day), who made it possible for the first time to employ experimental psychology to explain mental disorder in terms of psychological processes so that the path that modern psychiatry now treads may be said to have been paved by Emil Kraepelin. Later as the 19th century merged into the 20th, there arose in Vienna, another giant pioneer, namely, Sigmund Freud. The work of Freud gave us for the first time a grasp of the biological significance of the psyche as well as of the fundamental way in which it works. Psycho-analysis has now gone far beyond its first beginnings so that to-day it stands for a conceptual method of approach to any and every variety of mental disorder. The mechanisms of repression, condensation, identification and projection, and the concepts of ambivalence, the unconscious, archaic reactions and paleo-psychology are of profound significance and importance for psychology. The advent of psycho-analysis directed our attention for the first time to where the real trouble has taken place and centered our interest upon the actual mechanisms that are producing the symptoms. The result of all this is that present-day psychology covers, not one, but a number of activities all of which are dedicated to the pursuit of one purpose, namely to help mankind to a better, a fuller and a happier life. One product of this purpose has been the introduction into popular currency of the term "Mental Hygiene" and with it a broadening of the conception of public health to the end that already in many countries the cultivation of mental health is as much the concern of the Department of Public Health as is the cultivation of physical health. In India, however, no such advance has as yet taken place. We may presume that the advantages that would accrue upon such an outlook on communal welfare, have so far escaped the notice of our legislators. It is, therefore, my intention to devote the principal part of my address to placing before you some specific recommendations towards bringing about better co-operation between psychologists and psycho-pathologists for the establishment of a properly organised movement for the promotion of mental hygiene in this country. The general objects of such an association should be as follows : To work for the protection of the mental health of the community ; to help in the prevention of nervous and mental disorders and mental defects ; to help in raising the standards of care and treatment of those suffering from mental deficiency ; to promote the study of these subjects in all their form and relations and to disseminate knowledge concerning their causes, treatment and prevention ; to obtain from within India as well as from elsewhere reliable information regarding the conditions and methods of dealing with mental disorders and mental deficiency ; to co-operate in accordance with the policy of the association with the various departments and other

existing agencies concerned with these problems. I will now attempt to outline what might be a modest programme of work along these lines and in so doing I propose to follow more or less, certain suggestions of Prof. Morris Miller, Director of the Psychological Clinic of Hobart, Tasmania. As Professor Morris Miller has insisted, we should first endeavour to establish the term "mental hygiene" in daily use. Mental Hygiene is an euphonious term and pleasing to the ear. It is free from unfortunate associations; it has a positive aspect and carries with it something of hope. It has already gained world-wide recognition and stands for something definite in the regions of health. Dr. Lewellys F. Barker, sometime President of the United States National Committee, has well described the campaign for mental hygiene as a "continuous effort directed towards conserving and improving the minds of people . . . . . a systematic attempt to secure human brains so naturally endowed and so nurtured that people will feel better, think better and act better than they do now."

We have long been accustomed to the idea of getting and keeping oneself physically fit to meet the tasks of life; we need to reinforce that effort with the idea of getting and keeping oneself mentally fit. By all means let us develop sound bodies through which sound minds may function well, but let us also see to it that we develop sound minds that will function through sound bodies, and keep them so.

We have too long been satisfied with casualty work, redeeming the past of those who have gone down in the struggle. Now we are somewhat awake to the fact that we must need prepare ourselves beforehand to meet the evils of the mind and fight a way through them to positive achievements. The foundations for strength of mind, as well as for strength of body, must be laid and that too, well and deeply laid-in childhood. And so we come back to the everlasting demand of the ages, more adequate educational methods and more efficient educational service to develop more robust individuals for social service.

Many go even further and insist that we must of necessity consider the original endowments of human beings that are to be trained for life and for the passing on of life. We require better types of individuals and the preservation of existing types that meet the demands of the times. Accordingly, we must not merely salvage the wreckages, we must prevent their occurrence; and so push on toward social efficiency that we shall have to spend less time on redemptive work and more time on creative work—thus enlarging the scope of human service and giving it a place of stability on the heights of progress.

But truly we have a long way to go, and we have been an unconscionably long time in getting where we are to-day. Still we must go on. Though it is indeed something gained to

have a good name for a good cause, yet it is better far to get into action for the cause itself. Having sounded forth a new name, we must not be blind to the fact that it still leaves the old sores very much where they were, unless we can forget the things that are behind and go forth under the banner of a new movement with an enlarged hope.

Because mental hygiene problems go beyond what is purely medical and involve questions relating to social, educational and industrial conditions, it is imperative that if we are to advance in the attack against ideas and things that endanger the mental health of the community, we must bring together the specialists in medicine, education and social service into a common organisation. Team work is essential to success in these efforts as in so many others but the lead should lie with the members of our Association. By means of it the various outside interests in mental hygiene will be co-ordinated and apportioned values in accordance with their relation to the movement as a whole. At present this is distinctly lacking with the result that some push for the complete recognition of the claims of the feeble minded; others work in the field of delinquency; others are concerned with pressing Local Governments for more money for better treatment of patients in mental hospitals; others again plead for the special education of the super-normal child in the schools, and so forth. These fields of service are all separated from one another and are regarded as being apart, especially when funds are being demanded of Governments. What is urgently needed is a means of inter-adjusting their claims and giving them all their due status in a complete State programme of mental hygiene. This task of co-ordination and appraisal of sectional interests will be a first demand upon the organisers of a mental hygiene movement in this country. The difficulties that will have to be faced are of no mean order. I can do no more than merely touch upon them, but in so doing I ask your indulgence to speak plainly.

As far as psychiatry is concerned, it is quite fair to say that outside the walls of Mental Hospitals, the subject is almost totally neglected in India. Outside the hospitals, skilled psychiatrists are extremely few in number. In many of the largest towns in this country there is not a single specially qualified physician to whom a mental case can be referred for advice and treatment. As far as I am aware this is true of the wealthiest cities in India—Calcutta, Bombay, and Karachi. What makes this fact the more deplorable is that the medical profession and the general public appear to accept this situation as being in the nature of things for there is no sign at present of any effort to correct it. Presumably the medical and the general public consider special knowledge and skill to be indispensable to the proper management of a mental hospital,

but there is evidence that they hold this view neither in respect to the treatment of the individual before his admission into a Mental Hospital nor after his discharge therefrom. Even the discharge of a proportion of the patients admitted into the hospitals, when cured or improved, has failed to convince either the public or the medical profession of the possibilities attendant upon the application of proper treatment in the early stages of mental disorder. There is still the view that the study and practice of psychiatry can be of service only in the treatment of hopeless conditions. Now this attitude of mind on the part of the public forms a very serious obstacle to any attempt to get going a mental hygiene movement. Hence to correct public opinion on this point should be one of our principal objects. Experience in other countries has shewn that most effective measure to this end is the establishment, wherever possible, of out-patient clinics. The existence of such clinics brings the psychiatrist into touch with the general medical practitioners in a way that is mutually helpful. The latter get the opportunity to see the psychiatrist at work on cases with which the practitioner is familiar, and any help given tends to increase their interest in and respect for psychiatry. Then the educational value of such clinics may be advanced further by talks to school teachers and parents whose pupils or children have been examined at the clinic. Activities of this sort not only bring relief to sufferers but help to create among the public a feeling of confidence in psychiatry. The next move must be in the direction of starting a psychopathic ward in every hospital which is a teaching centre throughout India. But to bring this state of things into existence, more men are needed. Hence, I suggest for the consideration of those who are responsible for such matters, the creation of an alienist or psychiatrical department. This department may be an Imperial one or a Provincial one. On the whole, I favour development along provincial lines, because as far as my very limited knowledge goes, there is no rivalry at present between the various provinces in India to have the best Public Health Department. There certainly should be, and perhaps the introduction of this new branch of public health, the psychological branch, might give rise to it. From the very start we should insist that candidates for the psychiatrical cadre of the public health service, should have the best training that their Local Governments, or the Imperial Government, as the case may be, can give them. That is to say, they must not get their training necessarily in the province to which they belong by birth in order to gratify local snobbery. The subject is too important and too pregnant with possibilities of future development to be left to the tender mercies of the parish pump. If, later on, it is found that the facilities in India for an adequate training of these men (and possibly women too),

are not available, they must be sent abroad, either to Europe or to America. Nevertheless, until this proves to be the case, let us make a beginning with what is now at our disposal. Let us find out where are the best teachers for the subjects which have to be taught, and send pupils to them. In a few years each important centre in India will have a few trained psychiatrists who can at least begin to train the next generation.

Besides their ordinary work in connection with the psychopathic ward which would, of course, include regular instruction to medical students, our psychiatrists would organise the spread of psychiatric knowledge among the more cultured population of the great towns. By working in co-operation with the local magistrates, they would be in a position to aid materially in the application of proper judicial treatment to mentally deficient offenders against the law. To the Jail and to the Educational Departments, the psychiatric staff would be able to afford much of that help which both departments so urgently need.

The penologists in this country (and here I include barristers and pleaders along with judges and magistrates), are still very far from the realisation that the criminal is the State's greatest crime. Crime is not a detached or separable fact, self-contained and self-subsisting. It is only a symptom. It is a mental symptom with a mental origin. The study of the criminal has become a distinct department of psychology and the handling of the juvenile offender is, or should be, a practical application of known psychological principles. As Professor Cyril Burt has pointed out, with moral disorders as with physical, we must find and fight not symptoms but causes. To whip a boy, to fine him, to shut him up in a penal institution, because he has infringed the law, is like sending a patient, on the first appearance of fever, out under the open sky to cool his skin and save others from the infection. It is as blind and unintelligent as the primitive treatment of malaria when the parasite was unlooked for and the mosquito ignored. Our judiciary, our lawyers and our police have got to learn that the more intelligent section of their community has already realised that the treatment of crime does not so much rest with the investigation of the offence as with the investigation of the offender. Nowhere in India, as far as I am aware, is any attempt being made to do this. Our law-courts, our jails and our so-called reformatories continue as divorced from that definite body of ascertained psychological knowledge as they were fifty years and more ago. What is worse is that they appear content to remain so.

If the community of this country ever becomes sufficiently enlightened to provide justice for the poor, I think that they will probably adopt the American example of what are called

Courts of Domestic Relations. Judge Lindsey of Denver, Colorado, testifies as follows :

" I am judge at this time of what is known as a separate, special Court, in a city of nearly 3,00,000 people ..... this Court has jurisdiction over all children cases, and all youths under twenty-one, all cases of non-support or desertion of wives or children, and of all controversies of parents over their children, and practically all criminal cases where the accused has committed an offence against a child. Thus, it is a special tribunal for the correction and protection of children and some cases of domestic relations .... We have visitation and probation officers, medical clinics, physical and psychological, which aid and assist us. The work of this Court, in a word, is that of a piece of human adjustment .... The budget of this Court for all its work in its various divisions, last year, was about $30,000. I believe with you that would be about Rs. 78,000. This includes the salaries of the judge, the clerks, probation officers, stenographers, visitation agents, specialists, etc. We heard and disposed of about 3,000 cases last year at an expense of about $10 per case. When we have to send a youth to the State prison, jail or reformatory, we send him by himself on trust and honour, without an officer and without official restraint. Out of some eight hundred thus committed in the last twenty years, we have never lost a prisoner .... We very seldom swear a witness in the Court, and seldom take testimony .... We have no rules of evidence and no Court costs, and, as a rule, no lawyers or counsel or solicitor's fees. The judge of this Court is a human adjuster of human difficulties without cost or expense to the parties involved." Another American Judge writes as follows : " The Juvenile Court Procedure has all but disappeared. We do not believe that a Court Procedure has any therapeutic value in the handling of children afflicted with that which we term the disease of delinquency. It has been found possible for us to prevent the sending of children to the industrial schools, reformatories, or correctional institutes of any character. In this State we have an industrial school that has accommodation for 1,200 boys. Cincinatti has a population of 5,00,000 and is the second largest city in the State. Notwithstanding this fact, we have but two boys in the industrial school at this time and these two have been committed to that institution only because we have found them to be incurable and there is no other institution in the State that is equipped to handle cases of this kind. We hope to remedy this defect at an early date. We have sent no girls to the State industrial school for the last three years."

Our clinics, therefore, should also be centres for research and possess laboratories and equipment sufficient for carrying out these functions. The personnel of the mental hospitals and psychiatric clinics would require reinforcement by means of a

psychiatric social service. The social service worker should, of course, act under the direction of the psychiatrist. In India we are fortunate in the possession of many mission societies as well as a variety of social service organisations, from whom valuable assistance could be expected. Indeed, help from social service workers is being found in countries where mental hygiene organisations exist, to be almost indispensible not only for complete diagnosis and treatment, but also for after-care supervision, both in the family and in the vocational activity of the patient. Through the agency of the social worker the staff of the hospital or clinic are enabled to get a living picture of the patient's social surroundings, and to carry on remediable measures beyond the confines of the institution. I will now pass to a short consideration of the question of the protection, care and treatment of mental defectives. Here I may refer by way of a preliminary observation to the lamentable lack of provision for the feeble-minded throughout India. Individuals are being aroused everywhere to the appalling need for collective action, but up to the present this unfortunate class remains practically uncared for as far as legislation is concerned. In 1925, the Hon'ble Mr. Haroon Jaffer moved the Council of State to recommend to the Governor-General in Council that the Provincial Governments be asked to investigate the best means of dealing quickly and adequately with cases of mental defectives. A discussion followed which was remarkable only for the ignorance of the subject displayed by all who took part in it. The motion was eventually withdrawn. We must therefore instruct our legislators in the nature and the scope of the problem and impress on them that permanent results are not likely to be achieved without legal sanction to enforce treatment and care. To this end India must have a Mental Defectives Act. The next step to take should be a survey of each province as a whole as far as is practically possible. Schools, charitable institutions, child welfare societies, benevolent organisations, departments controlling the children of the State and the protection of infant life, and similar bodies, may all assist the survey by reporting or notifying suspected cases for examination. This latter method of notification, both before and after examination, is a very effective means for controlling the movements of mental defectives, especially the feeble-minded grade, before they finally leave the schools. In this way the central authority is kept in direct touch with all defectives attending schools and it is enabled to put into immediate operation legal methods for their guidance and protection in after-life. In all the large cities throughout India, it should not be difficult to institute special classes or special schools for the feeble-minded wherein each child receives a due amount of individual instruction to enable him to develop up to the limits of his mentality. A distinctive feature of these classes should be what is termed the.

sensori-motor training which is mainly provocational in character. Some of the children attending these classes may, under specialised instruction, go out into the community and earn a fair livelihood under favourable conditions. The greater number will require supervision in after-life while some will ultimately reach a custodial institution or training school. Besides the provision of special classes or schools for the feeble-minded, it is necessary to organise proper supervision over them. It is obvious that no province could possibly provide beds in institutions for the whole of its mentally-defective population, so we may take comfort from the knowledge that a large number of mental defectives, especially the high grade feeble-minded, may and do live well in the community under adequate supervision, when this supervision is carried out by trained social workers or by enlightened voluntary committees formed for the purpose. Wise and tactful administration on the part of supervisory officers, can confer lasting benefits upon individuals, so that the state ultimately gains in social efficiency. Further, it will be found possible to place certain cases under the guardianship of competent persons who are capable of appreciating the limited intelligence and the nature of reaction of their wards. Lastly, comes the creation of institutions for the permanent care of certain types of feeble-minded. Such institutions should be in the best sense training schools, and by proper classifications and distribution of their population, the inmates may by their services contribute in part to their support. Life in an institution may be made a very happy one; everything is provided that is necessary for the child's good, and however old they grow, they are never burdened with the care and responsibility of normal individuals.

The examination of the feeble-minded should be thorough and systematic. It should include a survey for identification and registration, and should be carried out by a psychological or psycho-educational clinic on whose staff there should be psychiatrists, psychologists, social service workers and clerks in proportion to the demands made upon it. The examination of each child should include four main fields of enquiry, medical, social pedagogical and psychological. The final determination should be a correlation of the results of the investigations made in all these fields of enquiry. The examination should be made in the interests of the child, with a view to determining the nature of his mentality and the kind and method of instruction and training that are best suited to his mental and physical conditions.

It will be part of the business of these psycho-educational clinics to assist in the training of special class teachers and others engaged in the instruction, protection and supervision of the mentally-defective, and it is here where so much help may be expected from the experimental psychologists.

While I have had in mind throughout this brief review some of the measures needful for those suffering from mental disorders and mental deficiency, I must not omit to remind you that the normal individual, whether adult or child, requires his due need of consideration. I will however leave to abler workers than myself the problem of advocating the association of mental hygiene with the life of our schools, colleges, and universities.

Most of us will agree with the opinion of Thomas Henry Huxley that the theory of evolution encourages no millennial anticipations, but, as Huxley said in his famous Romanes lectures on Evolution and Ethics, there is no limit to which intelligence and will, guided by sound principles of investigation, and organised in common effort, may help to change the nature of man himself. Anyhow, it is an essential condition of any realisation of whatever hope we permit ourselves to entertain of an abatement of the evil of the world, that we should cast aside the notion that the escape from pain and sorrow is the proper object of life. As Huxley said, we have long since emerged from the heroic childhood of our race, when good and evil could be met with the same 'frolic welcome.' The attempts to escape from evil, whether Indian or Greek, have ended in flight from the battle-field; it remains to us to throw aside the youthful over-confidence and the no less youthful discouragement of nonage. We are grown men, and must play the man,

> " . . . . . strong in will
> To strive, to seek, to find, and not to yield,"

cherishing the good that falls in our way, and bearing the evil, in and around us, with stout hearts set on diminishing it. So far, we may all strive in one faith towards one hope:

> " It may be that the gulfs will wash us down,
> It may be we shall touch the Happy Isles,
> ..... but something ere the end,
> Some work of noble note may yet be done."

Abstracts of Papers.

1. A dream of an ascetic disciple.

S. L. Sarkar, Noakhali.

Dr. Sarkar's paper deals with a dream which he found recorded in the published diary of Kulandananda Brahmachari, a disciple of the eminent ascetic, Sri Bejoy Krishna Goswami. The dream is discussed by Dr. Sarkar in respect to the symbolism—expressed in the manifest content. Dr. Sarkar then proceeds to show this dream exerted a remarkable influence on the dreamer's conduct when, later on, he was in waking life exposed to a considerable temptation.

2. On the love of music.

T. H. Thomas, London.

Captain Thomas considers that William James was quite in the wrong when he assigned such a low psychological value to the love of music. James held that "susceptibility to music has ..... no zoological value." Thomas attributes James's opinion to a too rigid adherence to introspection of psychology as well as to James's failure to appreciate the value of conduct. He cites Shand's conception of "sentiment" as the organisation of a system of emotional dispositions about the various objects and classes of objects responsible for the excitation of such emotional dispositions. Thomas goes on to maintain that all character depends for its existence upon the dominance of some sentiment capable of organising these emotional dispositions. Arguing from the well recognised influence of sentiment on religious belief, Thomas tries to shew that the sentiment for music, at any rate for those who have it, plays a signficant part in distinguishing between the harmonies and disharmonies of life. Further, music promotes the active expression of the feeling of sympathy and assists the processes of sublimation. On these accounts, the love of music, like any other component of the aesthetic sentiment, is of great value to social development.

3. Studies in Psychodynamics. Applications in Criminal Law.

S. Sankara Menon, Trivandrum.

The paper deals with some of the psychological problems and their application in criminology. Criminal responsibility and its exemptions ultimately rest upon the doctrine of free will. The extent of the operation of free will has its own limitations in the light of the Freudian theory of the unconscious. The laws and the methods of suggestion operating in the unconscious, the transmission, the effect of suggestion, the forces underlying the same were investigated and studied by the author and a short article on the subject was published in the Indian Review for 1916. In the present paper, he has stated how these methods could be applied in psycho-galvanic experiments. He has also discussed therein how a step may be taken by way of reform to improve our notions of criminal responsibility in the light of the above investigations.

4. Echoes of a psychology of dreams in Upanishads.

R. N. Sarma, Madras.

The point of departure for the discussion to the theory of Freud that a dream is a fulfilment of an antecedent wish—a wish too with a pre-eminent sexual tinge. (2) Stand is taken on a passage in the Prasnopanishad (the Fourth Prasna) that maintains that a dream is the result of the free and unbridled exercise of the subject's creative activity. (3) One can—to put it exaggeratedly, stake his all on the significance of the term *Mahima* in the given context. (4) Freud's interpretation of dreams is too narrow and onesided. (5) In later medical-literature Unmada is studied in its etiological therapeutic aspects. (6) Some sort of Psychiatry was known in ancient India. (7) The Upanishadic interpretation is more natural and less strained than that of Freud. (8) The Unconscious plays a prominent part in the creation of dreams and the regulation of dream-activities. The Unconscious is collectively termed the Vasana. (9) The dream-phenomena must be regarded to be beyond good and evil. (10) A well-disciplined life according to the ideals of *Vairagya* would not create many bad dreams and it feels no need for any pleasant ones.

5. The place of Consciousness in mental life.

P. B. Adhikari, Benares.

There are two extreme positions with regard to the question of the relation of consciousness to mental life. The older view, still upheld by many in the present day—would identify the mental with the conscious, they being regarded as coextensive. The other extreme position, represented by Behaviourists in Psychology and some modern Realists, would regard the mental as unconscious, consciousness being supposed to have no place in the mental life. Both the positions are untenable in view of direct evidence of experience. The true position appears to be the middle one—mental-life is conscious and unconscious both, the unconscious forming the largest part of it. This positition is also represented by many eminent psychologists of the day.

This third and intermediate position, though true to facts, does not solve the problem. The relation of consciousness to mind remains still a mystery. Any attempt to solve the mystery must proceed by defining, if possible, the terms 'consciousness' and 'mind.' But consciousness, in its very nature, is so unique and unanalysable that it does not admit of any definition. We know that it is there, but cannot say what it is *like*. The term 'mind' again, if used to denote a *substance* in the old and scholastic sense, is not admissible in the present day. There is no mind as distinct from the *mental*, paradoxical though it may sound. Nor can mind be identified with the brain, as the Materialists would have it from this mechanistic position. The only defensible position remains that there are mental facts, some of which are conscious, and some (forming the larger part) unconscious. The problem we have to do with here is, therefore, what conditions made this difference in the facts ?

One admitted condition is attention, with the degrees of concentration and relaxation of which goes usually consciousness to and its gradual withdrawal from the facts. But attention, though it is usually accompanied by the appearance of consciousness, is not the sole condition there. It only prepares the ground for the appearance, but does not determine it always, as instances of mental concentration without knowledge of the facts wanted by the concentration show. The advent of consciousness is, therefore, something mysterious. This shows, at least, that this advent has not organic connection with the mental life. Consciousness is, therefore, something internal to that life.

The mental life is thus unconscious in its very nature, though at times

it is enlightened by the 'grace' of the conscious entirely, whatever it may be. As such, the mental life has to be studied as part of and in continuation with the vital, as is being done in the present day by many psychologists. Here lies the true function of the scientists of mind. The nature and work of consciousness may be wisely left to the consideration of the philosophy of mind. Thus there is no proper antagonism between the scientist and the philosopher here, as it is nowhere else.

6. The Behaviorist stand point.

K. S. Ghosh, Hazaribagh.

An attempt is made in this paper to examine some presuppositions of Behaviorism—an interesting development of modern Experimental Psychology.

Behaviorism conceives of a unitary scheme of psychological development and is exclusively genetic in its out-look and method. Though quite radical in some of its conclusions its inspiration is as old as the time of Aristotle.

It seems to have committed itself at least to the following presuppositions viz. (1) that all behavior is interpretable in terms of stimulus and response: (2) that introspection is ineffectual as a source of knowledge: (3) that there is no imagery or imaginational thought. Each of these is open to very serious objections.

The following objections can be urged against the lst presupposition (1) Mere Tropisms fail to account for the movements of even unicellular organism. They utterly fail to account for higher forms of activity. (2) It ignores the functions of inhibition in animal behavior: (3) The so-called telegram argument further shows its inadequacy.

The rejection of introspection is the weakest link in the chain of Behaviorist argument. A consideration of the nature of imagery and sensation shows that introspection is a genuine source of knowledge.

The behaviorist repudiation of imagery is due to confusion between free and what James Ward called "tied or implicit idea."

The researches of Galton tend to strengthen the case for imagery.

The results of Psycho-analysis go against the Behaviorist stand point. The behaviorist technique though immensely helpful in animal psychology seems utterly unequal to the task of fathoming the depth of human psychology.

7. Interpretation of insane conduct.

Frank Noronha, Bangalore.

Psychological concept of insanity, its scope and its practical application.

Mental disorder viewed from the stand-point of the individual and the environment, and psychologically considered to be a re-adjustment or a reaction on the part of the individual.

Self satisfaction is the primary aim of the individual afflicted, and the principle of purposive activity applicable to insane behaviour.

Syntoid and Schizoid types of behaviour, exemplified in different psychoses.

Frequency of schizoid types of behaviour in mental patients and the diversity of its manifestions.

Flight of the Psyche and the varieties of flight from reality.

Psychopathology in its relation to physiology and psychology.

Insane behaviour in its relation to healthy behaviour.

Aberrations in normal behaviour, the insane being the advanced type.

The study of normal psychology is advanced by the study of the morbid mental state.

8. Inferiority complex.

H. D. Bhattacharyya, Dacca.

In this paper an attempt has been made to connect certain facts of social adjustment with the help of the supposition that certain persons suffer from a sense of inferiority.

9. The combination of speed and quality in Bengali handwriting.

Jogendra Chandra Dutt, *and* Devendranath Sarkar, Dacca.

An experiment was made to determine whether Gates' formula for combination of the scores of speed and of quality in handwriting is applicable to Bengali handwriting. It appears that the formula is applicable.

10. The choice of future profession of 1013 Bengali boys.

S. K. Bannerjee *and* H. C. Mukerjre, Dacca.

University students are tending in greater numbers to seek commercial, industrial and scientific careers, rather than the Law, Government service and the professions generally. The ambitions of school boys show little reflection of this change: 21% desire to be lawyers, 18% desire to be medical practitioners, 16% to be engineers, 9% to be professors, 5% to be teachers, 4% to be Deputy Magistrates; the remaining 8% mention miscellaneous occupations. A study was made of the favourite school subject of boys selecting the various occupations; there is no relationship between the choice of subject and choice of profession. The favourite subjects were—in 36% cases English, 18% History, 17% Arithmetic, 9% Bengali, 6% Algebra, 4% Drawing, other 10%.

11. The superstitions of Bengali teachers.

Ainul Quari, Dacca.

An investigation was made by Russell Gould of the superstitions of women in Scottish Colleges. A similar investigation was made of men in the Dacca Teachers' College. The number of superstitions mentioned per subject is equal in the two cases; the percentage of students unaffected by any superstition is greater in the case of the Bengalis. Eight superstitions are common to Scotch women and Bengali men.

12. The effect of knowledge of the purpose in the marking of compositions.

Aswini Kumar Datta, Dacca.

It has been maintained that every written composition has (or should have) reference to a definite 'audience' or purpose and can be evaluated only in reference to that audience or purpose. An experiment was made to determine the effect of knowledge of the purpose on the marking of essays. Fifteen boys were set the essay 'Describe your home as to an absent brother who has never seen it,' and another fifteen were asked to describe their homes as to a prospective buyer. Twenty teachers marked all the essays without knowledge of the purpose. A week later the same teachers marked the essays again, the purpose of the essays being communicated to them. The result was negative.

13. The reliability of essay marks.

ASWINI KUMAR DATTA, Dacca.

Thirty essays written in Bengali on the subject ' A description of my home ' by boys of class IX of a High School were examined by 24 teachers in 1921. There was as much variation among the several examiners as to the value of each paper as there was variation among the several papers in the estimation of each examiner. The intercorrelation of the examiners (*l*) with the pool of the other examiners ranged from 0·34 to 0·85. The intercorrelation between the marks of the different examiners ranged from 0·28 to 0·67.

Fifteen of these essays were re-examined by 16 fresh examiners in 1926. The results were much the same as before.

The remaining fifteen essays were re-examined in 1926 by 11 examiners who took part in the examination of 1921. The correlations between the marks assigned in 1921 and 1926 by the same examiners ranged from 0·42 to 0·82.

The above results emphasise the fluctuating and subjective nature of a judgment on an essay and bear witness to the unreliability of the essay type of examination.

14. Psychology and the school text-book.

MICHAEL WEST, Dacca.

Modern teaching practice has transferred much of the emphasis from the teaching process to the learning process. It has therefore thrown a new responsibility on the writer of the text-book, and a number of attempts have recently been made to place the evaluation and construction of school-books on a more Scientific basis.

The construction of a text-book involves five processes—analysis of the need, analysis into the component mental functions by means of ' pure ' tests, construction of a practice system, adaptation and experiment and measurement, and finally construction. A text-book must comply with five criteria. It must supply direct practice, under real conditions, producing uniform progress; the child must be conscious of his progress. The result must be achieved at a minimum cost of the pupils' time and money.

15. Error in the ages of Bengali Boys.

AINUL QUAVI, Dacca.

It is a condition of intelligence testing in any country that the true ages of children should be easily and accurately ascertainable. A study was made of the ages of 746 boys in Primary Schools in Dacca Division. Five methods were used for determining the true age. The average difference of the child's own statement from the truth was 6%; of the teachers' estimate 5%, of the admission register, 18%. In the register the error tends to increase with age, ranging from 8% at age 6 to 35% at age 19. Such conditions render intelligence testing on an adequate scale quite impossible.

16. Forgetting and Amnesia.

J. K. SARKAR, Muzaffarpur.

General statement of the problem—the distinction between forgetting and amnesia caused by repression is only relative.

The consideration of the total quantity of memory—materials and their proper classification support the above suggestion and lead to the

probability that there is no fundamental difference between the Normal and the Abnormal mind.

Certain differences between the mode of functioning of memory in the two cases (Normal and Abnormal mind) seem to be qualitative. But, that this distinction is not qualitative is proved by the following:—

(i) A general survey of the process of Psycho-analytic cure with the help of the principle of positive transference.

(ii) A consideration of the substitute material used by the process of repression.

Conclusion.—Probably the same memory mechanism underlies both forgetting and amnesia. And reproducibility, which is the criterion of memory depends to a great extent on the consilience of memory materials with the attitude of the Ego.

17. Some factors in the psychology of advertisement.

Suhrid Chandra Sinha, Calcutta.

The paper presents the data obtained from a series of experimental investigation regarding the memory-value of the different elements of a particular type of advertisements. The selected advertisements consist of three essential elements: (i) a pictorial representation, (ii) a description of the commodity, (iii) the name of the firm. The method consists in the determination of the perseverative tendency of these factors.

18. Vocabulary study of two children, 3 years and 4 years old.

Gopeswar Pal.

The paper reports a series of observations upon the vocabulary of two children with respect to the following points: (1) the frequency of particular sounds, vowels and consonants; (2) the frequency of different parts of speech; (3) the frequency of sounds that are thus pronounced; (4) the size of the vocabulary.

19. Perception of forms in indirect vision.

Suhrit Chandra Mitra, Calcutta.

Sanford notices that if a person fixates a point on a piece of paper and then tries to arrange in a straight line three pin heads at some distance from the fixation point, the line joining the pinheads is always a curve. The experiments reported in this paper follow up this investigation. It is an attempt at a termination of the correlation between distance from the fixation point and the amount of curvature perceived. A further attempt is made to compare the perception of certain geometrical forms in direct and indirect vision.

20. Monocular perception of distance.

Sudhir Kumar Bose, Calcutta.

Perception of distance is essentially binocular. Monocular perception of distance involves a large amount of error. The paper presents a series of experiments in continuation of those reported in the Indian Journal of Psychology, Vol. 1, No. 4. The writer has attempted to correlate the variation in the amount of error with the variation of the distance of the objects to be judged from the eyes of the observer.

21. A suggestion of a new method for the demonstration of Weber's law in the field of visual brightness.

HARIPADA MAITY, Calcutta.

Weber's law depends on the constancy of a ratio between the just noticeable change of stimulus and the original stimulus. The photometric principle of inverse proportion between intensity of the illumination of a known field and its distance from the source of light has been here used to correlate the intensity of the stimulus with the J.N.D. of brightness sensibility. Two square fields cut out from the same paper and illuminated from a single source of light of a known candle-power are observed by the subject in a dark room through an aperture, so that equal portions of the fields are seen at the same time. One of the fields acts as a comparison field while the other is moved towards or away till the J.N.D. of the sensations of the two fields is obtained. An attempt has been made to verify Weber's law in different ranges of the intensity scale. The relative advantages of the method are indicated.

22. The influence of musical notes upon tremors.

MANINDRANATH SAMANTA.

The paper presents the result of a series of experiments in continuation of those reported at the Section of Psychology of the last session of the Science Congress and published in the Indian Journal of Psychology, Vol. I, No. 4. The tremors in question are of very small amplitude and have been recorded from one of the fingers. They maintain a fairly constant average frequency under normal conditions. The frequency shows a small increase under the influence of certain musical tones.

23. A study in the increase of subjective brightness in a circumscribed field.

M. N. BANERJI, Calcutta.

The paper presents the data of a series of experiments in which a field was seen through tubes of different diameters. There is a change in subjective brightness inversely with the diameter of the tubes. The phenomenon has been studied in diffuse day light as well as in the condition of dark-adaptation. The change in the brightness value of colours has been similarly studied.

24. On Gestalt-Theorie.

N. N. SEN GUPTA, Calcutta.

The paper traces the historical connections of the 'Gestalt-Theorie' and its raison d'être. The principal experiments upon which the theory is based are critically examined. The change in outlook in regard to experimental work and theoretic assumptions, which acceptance of the view would involve, is surveyed in brief.

25. Intelligence tests for college freshmen.

G. C. CHATTERJI, Lahore.

The paper reports the results of an intelligence test given to first year students of the Government College, Lahore. It discusses the suitability of various tests, the method of administration, scoring, etc. Comparison of results obtained with the University Matriculation Examination, suggested the desirability of a supplementary memory test, which was duly adminis-

tered to the same group of students, and the results obtained have been made the basis of certain reflections on the relative values of intelligence and memory in determining the marks obtained by the candidates in the Matriculation Examination of the Punjab University. These conclusions are admittedly conjectural and further enquiry is being undertaken to substantiate them.

26. The comparative value of some single tests as measures of general intelligence.

Mohammad Aslam, Lahore.

The paper draws on the data obtained by a group intelligence test administered to first year students of the Government College, Lahore, and reported in a paper by Professor G. C. Chatterji. It exhibits in the form of table the correlation between one another of the individual tests and also between each of the tests and the general intelligence score obtained by the summation of all the ten. Certain suggestions are offered as to the comparative value of single group tests of intelligence when a large number of them can be administered.

27. Retention by visual and by kinaesthetic presentation.

Mohammad Aslam, Lahore.

The paper reports the results of a brief investigation designed to bring out the relation, if any, between retention by visual and retention by kinaesthetic presentation. The material of presentation in the two cases is as similar as it can be made ; it consists of a series of nonsense figures, each made out of the same number of components of a constant nature. Retention in both cases is tested by recognition out of material allowing only a small percentage of chance.

28. McDougall's theory of laughter at the ludicrous.

Raja Ram Kumar, Lahore.

McDougall says that laughter is a device of nature to save us from the pain of sympathy. The nature of ludicrous situations and objects is such that if we contemplate them without laughter, we shall sympathize with them and feel the pain and distress attendant on sympathy. So that nature has invented laughter as an antidote to sympathy and the pain which follows it.

This does not seem to be correct. Nature could not have been averse to the pain of sympathy. The pain of sympathy is a great social factor and has led to the survival, integration and unity of society. Nature could not have brought into existence anything to destroy that vital element in society.

The truth is that laughter is the expression of the instinct of self-assertion. When we laugh, there is a feeling of superiority at the fact that we at that moment are free from the defects and shortcomings of ludicrous situations and objects, their mal-adjustment, inappropriateness, incongruity and awkwardness. All sense of superiority is pleasing; all submission painful. That is why laughter is pleasant. There is no need of regarding laughter as a separate instinct. For the economy of hypothesis it may well be regarded as a particular expression of the instinct of self-assertion.

29. Mysticism and Psychology.—An exposition of a psychological approach to the problem of the truth of Mysticism.

Wendell M. Thomas, Jr., Lahore.

Neither the psychologist nor the mystic, but only the philosopher is properly equipped to evaluate mysticism. Psychology, however, by abstracting the common elements in all varieties of mysticism, can help us to understand it. Furthermore, by defining certain dominant types, psychology can help to clarify the issues preparatory to evaluation. For example, all mysticism seems to traverse the three psychological stages of analysis, synthesis, and complete union. But each stage with a practical mystic, for instance, will differ sharply from the corresponding stage with an ascetic mystic. To discover the ultimate meaning of this difference is a task for philosophy utilizing the social and normative sciences.

30. International group mental tests.

Stuart C. Dodd.

The U.S. National Research Council's investigations of problems of Human Migration. The "International group mental tests," by Stuart C. Dodd, Princeton. Report on the Indian group of 400 boys and girls examined by this scale and by the Hindustani-Binet.

31. Psychogalvanic and Psycho-circulatory reflexes of sense-stimulation.

I. Psychogalvanic Reflex.

The fundamental principle on which the electrical response is based is the fact that *any upsetting of molecular equilibrium sets free a current.* This is true of living as well as of non-living objects. A piece of wire placed in a galvanic circuit will set free a tiny current if it is twisted and cause the spot of light on the scale of the galvanometer move away from its position of rest, to which, however, it will gradually come back when the wire is untwisted. A twig severed from the parent plant, will similarly cause the spot of light to move quickly away and come to the point of rest again as the excitement passes off. If we put two skin points in contact with the terminals of a galvanometric circuit, a current will be produced. But rest will bring back the light spot to O. If at this point a stimulus is applied which is physical or psychophysical in character, the light spot will move away from O, and the volume of the electrical response will be, within certain limits, proportionate to the intensity of the stimulus. The curve obtained from a piece of wire in galvanometric circuit is a purely *physical* effect of twisting; that from a twig, similarly placed, is a *physiological effect;* and the result obtained by skin contact and sense or brain stimulation is a *psychophysical* effect.

(*a*) Apparatus used.

A highly sensitive galvanometer with non-polarisable electrodes, dipped in two non-conducting dishes of saline solution into which finger-tips are plunged for completing the circuit is the simple arrangement used for recording the psychogalvanic responses for sense stimulation.

(*b*) The operation.

As soon as the finger-tips are plunged in the dishes, there is a good contact current. This is allowed to come to O by making the subject remain perfectly quiet. At O, a sense stimulus is applied which causes deflection and this deflection is recorded.

(*c*) Effect of continuous stimulation.

If stimulation is continued for a long time, the galvanometer records a complete fatigue curve. The first stage is that of excitation which

gradually passes into a depression. A taste or smell, though pleasant at the outest becomes unpleasant and concomitantly with it the curve descends into a depression.

These curves are exactly like those I obtained by psychophysical stimulation i.e., mental work. The result is the same when a twig is subjected to continuous stimulation.

II. Psycho-circulatory reflex.

Sense stimulation is reflected on the pulse and can be recorded by means of a Sphygmograph. As usual, the first stage is that of excitation, which, with continuous stimulation, gradually passes into a depression, and the sensation if at first pleasant becomes unpleasant to the subject experimented upon.

Experimental formation of Psycho-physical complexes.

Suggestions made during a hypnotic trance operate after the trance is over, and the subject though unconscious of the suggestions, continues to follow them. Strong subconscious influences can in this way be generated for combating undesirable Psychophysical fixtures which are congenital or acquired.

32. Space limen in relation to the axis of rotation in the right arm.

KSHIRODE CHANDRA MOOKHERJI, Cawnpore.

For purposes of this experiment the whole limb was divided into three parts, viz. A, representing the portion between the tip of the middle finger and the wrist; B, representing the portion between the wrist and the elbow; and C, representing the portion between the elbow and the shoulder. As between any two of these portions the results of Vierordt's experiments were found to be correct; but they were found to be subject to exceptions when within any one of these portions smaller parts were compared.

33. Statistical ethics.

G. HANUMANTHA RAO, Mysore.

The paper describes the results of two tests in "Moral Evolution" carried out (A) with two groups consisting of 50 village school masters and 50 University students respectively and (B) with 200 University students, comprising the Mohamedan, Brahmin, Lingayet and Vokkaligar communities.

34. Experimental tests in the mental imagery of school children.

RAM KUMAR CHAUBE.

The paper summarises the results of experiments made in the D.A.V. High School, Benares, with children of the ages from 6 to 9 representing the principal races and nationalities of India. The present experiment was arranged in such a way that the various senses were simultaneously appealed to so that the habitual mental imagery of the individual found its natural selection by itself, which has not been usually done in other experiments of this kind. For visual imagery various toys, pictures and written sentences were shown. For the sense of hearing six songs in Bengali, Hindi, Urdu, Gujrati and English were sung, while for the tactual and motor imagery, the children were made to note things inside their desks by means of their hands. Of the 20 boys experimented upon the results are as follows:—

15 had visual type of memory, 2 auditory, 1 tactual and motor and 2 had equally visual and auditory type of memory.

INDEX.

Absorption of light in the ultraviolet, 145.
Acanthocephalan worn, a new genus of, 194.
Acanthogyrus, 194.
Acenaphthpyridine. some derivatives of, 156.
Acetyl cycloketones, interaction with diazonium salts, 150.
4-Acetylamino-3-chloro-phenyl stibinate of sodium—Preparation of, 163.
Acetylation of diamine, 164.
Achyranthas aspera Linn., 216.
Acoustics of the pianoforte, 97.
Acridine and indol derivatives containing an α-pyrone ring, 154.
Activated sludge—Sulphur oxidising organisms from, 34.
Activated sludge, microglora of—Sulphur oxidation on, 34.
Acton, H. W. Sarcoids or acquired angeiomata, 277.
Acton H. W. Tropical neurasthenia, 278.
Acton, H. W., and J. P. Bose. Colour of rabbits and their susceptibility to insulin, 274.
Acton, H. W., and R. N. Chopra. Causation of epidemic dropsy, 277.
Acton, H. W., and S. K. Mazumdar. Method of determining temperature of small insects, 274.
Acton, H. W., and S. S. Rao. Cause and aetiology of filarial lymphatic obstruction, 279.
Adhikari, P. B. Place of consciousness in mental life, 320.
Adittanallur—Human crania excavated at 307.
Adsorbed substances, effect of direct and alternating current electrolysis on, 143.
Adsorbed substances, theory of equation of state for—Experimental contribution to, 137.
Adsorption of chemical elements by bacterial bodies, 270.
Adsorption and coagulation of staunic hydroxide sol, 144.
Adsorption of colloidal solutions and of ions by freshly prepared precipitates, 140.
Aggarwal, A. L., and others. System $(NH_4)_2$ SO_4—H_2SO_4—C_2H_5OH, 135.
Agglutinins in the blood of healthy carriers of Koch's vibrio, 268.
Agriculture : Presidential address, 27.
Ahmed, K. M. Fossil wood from the Utatur cretaceous, 237.
Ajwan oil—Cymene from, 169.
Algae, sub-aerial blue-green—of Rangoon, 209.
Algal flora of the Chilka Lake, 209.
Alimchandani, R. L. *See* Shah, N. M., and R. L. Alimchandani.
Alkaline ferricyanide, action of—on silver nitrate solution, 132.
O-alkyl ketones, synthesis of, 155.
Aluminium hydroxide—A new scaly variety of, 160.
Amalgams, sodium and potassium—Viscosity of, 141.
Amidines, chromoisomerism in, 149.
Amin, B. M. *See* Puri, A. N., and B. M. Amin.
Amino-compounds, aromatic—Simultaneous diazotisation and nitration of, 149.
Ammonia, effect of varying concentrations of—on the nitrifying power of the soil, 33.
Ammonia, production of—by soil fungi, 34.
Ammonium carbonate solutions, hydrolysis of, 141.
Amnesia and forgetting, 323.
Amœbiasis, pathology of, 280.

Amsacta albistriga—Function of anterior tibial spurs in, 199.
Amylase from *Andropogom sorghum*, 166.
Anaemia and sprue, cases of—in Bombay, 263.
Anærobic infections in India, 267.
Anand, C., and D. Nath. Resistance of a nickel wire beyond the elastic limits, 95.
Anand, P. L. Root nodule organism of the leguminous plants, 210.
Anand, P. L. Two species of mimosa, 217.
Andropogom sorghum, amylase from, 166.
Andropogon sorghum—Correlation between yield and some prominent characters in, 32.
Andropogon sorghum var. *Technicus*, attempt to introduce and acclimatise—with seed introduced from N.-W. Italy, 32.
Angami Nagas—Calendar of, 302.
Anilides of 2 : 3-oxynaphthoic acid—Hydrolysis of, 152.
Annett, H. F. Seasonal composition of well waters as a means of study of soil nitrification changes, 33.
Anthropology—Some objects of, 300.
Anthropology and administration, 285.
Antiseptics, action of—on bacteria, 270.
Aphids and lady-bird beetles, 35.
Apte, V. V. *See* Singh, B. N., and V. V. Apte.
Aquatic vegetation of Bengal, 223.
Aqueous crystals, factors governing the hygroscopicity of, 138.
Arc spectrum of bismuth, 81.
Arora, G. L. Fresh water entomostraca of Lahore, 198.
Artificial pneumothorax therapy in India—Aspects of, 266.
Aryl and alkyl substituted cyan-acetamides—Preparation of, 173.
Aslam, M. Retention by visual and by kinaesthetic presentation, 326.
Aslam, M. Single tests as measures of general intelligence, 326.
Asteriastigma Macrocarpa—Oil from the seeds of, 162.
Asthma, treatment of, 281.
Asundi, R. K. Atomic structure of salts and the physical properties of their solutions : Viscosity and surface tension, 136.
Athawale, D. Y. Detecting adulteration in ghee, 168.
Atomic numbers, lower—K_α doublet in the elements of, 83.
Atomic physics, 75.
Atomic structure of salts and the physical properties of their solutions, 136.
Aulacophora abdominalis Fb. (Coleop.) and *Dysdercus cingulatus* Fb. (Rhynchota), 198.
'Avaram' bark, studies in, 170.
Avena sativa—Influence of light and darkness upon, 221.
Awati, P. R.—Fauna of the Bombay shore, 206
Awati, P. R. *Hydra* of the Bombay Island, 190.
Awati, P. R., and H. Rai.—*Ostrea cucullata*, 195.
Awati, P. R., and K. R. Karandikar. *Oncis Martensi*, 196.
Ayyangar, A. A. K. Bakshali manuscript, 93.
Ayyangar, A. A. K. Josephus problem and its extension, 94.
Ayyangar, A. A. K. Perspective-criterion for the double contact of two conics, 94.
Ayyangar, G. N. R., and P. K. Rao. *Eleusine coracana*, 224.
Ayyar, C. V. R. Sulphur oxidising organisms from activated sludge, 34.
Ayyar, M. V. Simplification of persymmetric determinants, 89.
Ayyar, M. V. Special cubic curve, 93.
Ayyar, M. V., and M. B. Rao. Coefficients in a certain trigonometric expansion, 90.
Ayyar, M. V. *See* Rao, M. B., and M. V Ayyar.
Ayyar, V. K. Carcinoma among cattle in the Madras Presidency, 276.
Ayyar, V. K. Tuberculin test, 275.
Ayyar, V. K. Tuberculosis among cattle of the Madras Corporation, 276.

B. lepra murium—Tumours caused by intraperitoneal inoculation of, 264.
Bacillary dysentery—Gram-negative non-lactose-fermenting bacilli in the causation of, 269.
Bacteria—Action of antiseptics on, 270.
Bacteria—Action of tropical sunlight on, 269.
Bacterial bodies—Adsorption of chemical elements by, 270.
Bacteriological efficiency of mechanical gravity filters, 271.
Bahl, K. N. *Eutyphoeus waltoni*, 195.
Bakshali manuscript, 93.
Bal, D. V. Effect of varying concentrations of ammonia on the nitrifying power of the soil, 33.
Balasubrahmanyam, R. Parthenogenesis in cotton, 224.
Banerjee, G. *See* Sen, R. N., and G. Banerjee.
Banerjee, H. K. *See* Guha, P. C., and H. K. Banerjee.
Banerjee, K. *see* Panja, G., and K. Banerjee.
Banerjee, N., and J. K. Basu. Adsorption of chemical elements by bacterial bodies, 270.
Banerjee, N. L. Manufacture of sodawater from the chalk-derived water of a deep tube well, 273.
Banerjee, P. C. *See* Ray, P. R., and P. C. Banerjee.
Bannerjee, S. K., and H. C. Mukerjee. Choice of future profession of 1013 Bengali boys, 322.
Bannerji, D. Poisson's ratio tester, 96.
Banerji, M. N. Subjective brightness in a circumscribed field, 325.
Bara soil—Gypsum in the reclamation of, 35.
Barat, C. *See* Sen, H. K., and C. Barat.
Barkla-effect with scattered X-radiation, 101.
Basu, C. C. Staining Lieshman-Donovan bodies in the tissues, 270.
Basu, J. K. *see* Banerjee, N. and J. K. Basu.
Basu, J. K. *See* Mukherjee, J. N., and J. K. Basu.
Basu, M. M. *See* Ukil, A. C., and M. M. Basu.
Basu N. M. Action of cobra venom on heart, 281.
Basu, N. M., and H. M. Sen Gupta. Stress and strain in elastic plate under the action of a couple at the corner, 95.
Basu, P. N. Cases of anæmia and sprue in Bombay, 263.
Basu, P. N. *See* Dive, G. H., and P. N. Basu.
Basu, S. C. *see* Das, P. N., and S. C. Basu.
Batham, H. N., and S. Nigam. Seasonal variations of the nitrite content of soils, 33.
Batra, B. L. *See* Luthra, J. C. and B. L. Batra.
Batrachian and reptilian remains in the Panchet beds at Deoli, 240.
Behaviorist stand point, 321.
Bengali handwriting—Combination of speed and quality in, 322.
Bengali women's charms for stopping storms, 305.
Benzaldehyde and toluene—Photochemical oxidation of, 147.
Benzene, bromination of, 148.
Benzene nucleus, influence of substituents in, 149.
Benzidine inversion in bis-hydrazo compounds, 159.
Benzylidine ketones, condensation of, 153.
Berkeley-Hill, O. A. R. Psychology : Presidential address, 309.
Beryl from Nellore—Occurrence and composition of, 238.
Bhabrao, G. D. *Corous insolens*, 191.
Bhabrao, G. D. Three new trematodes from reptiles, 191.
Bhagvat, M. B., and J. L. Simonsen. Constitution of the acid formed by action of sulphuric acid on camphorquinone, 156.
Bhalia, I. D., and others. Chromatic emulsions, 140.
Bharadwaja, Y. Scytonemataceæ, 209.
Bhat, V. N. *See* Naik, K. G., and V. N. Bhat.
Bhat, Y. N. *See* Naik, K. G., and Y. N. Bhat.
Bhate, S. R., and K.H. Hasan. Cymene from ajwan oil, 169.
Bhate, S. R., and K. H. Hasan. Storage of 'Mohwa' flowers, 169.

Bhatia, B. L. Freshwater rhizopods and flagellates from Kashmir, 189.
Bhatia, B. L. Parasitism among protozoa, 189.
Bhatia, B. L., and A. N. Gulati. Parasitic ciliates from Indian frogs, toads, earthworms and cockroaches, 188.
Bhatia, S. L. *See* Bhatnagar. S. S., and S. L. Bhatia.
Bhatnagar, S. S. and S. L. Bhatia. Effect of direct and alternating current electrolysis on absorbed substances, 143.
Bhatnagar, S. S., and S. L. Bhatia. Indices of refraction of some organic crystals and of inorganic salts in aqueous solution, 136.
Bhatnagar. S. S., and S. L. Bhatia. Special features of organo-sols, 142.
Bhatnagar, S. S., and others. Chromatic emulsions, 140.
Bhatnagar, S. S., and others. Effect of dyes on the lustre of silk fabrics, 164.
Bhatnagar, S. S., and others. Effect of impurities on the intensity and colour of phosphorescence of calcium sulphide 137.
Bhatnagar, S. S., and others. Effect of time on the gelating sols, 140.
Bhatnagar, S. S., and others. Factors governing the hygroscopicity of aqueous crystal, 138.
Bhatnagar, S. S., and others. Studies in photo-sols, 141.
Bhatnagar, S. S., and others. Surface reflectivity of liquids, 138.
Bhattacharyya, D. K. Spectrum of argon, 77.
Bhattacharyya, H. D. Inferiority complex, 322.
Bhave, S. D. *See* Prasad, Mata, and S. D. Bhave.
Bhide, R. K. Rice crop at Karjat, 222.
Bilinear forms—Invariants of a pair of, 98.
Bi-plane, variation of lift of—with the angle of attack, 85.
Birds of the district of 24-Parganas, 205.
Bis-hydrazocompounds—Benzidine inversion in, 159.
Biswas, K. Algal flora of the Chilka Lake, 209.
Biswas, K. Aquatic vegetation of Bengal, 223.
Biswas, S. C. Ionisation potentials and atomic sizes, 75.
Biswas, S. C. Ionisation potential and periodic classification, 75.
'Blast' disease of rice and its control, 211.
Bose, D. M. Irregularity of the K_a doublet in the elements of lower atomic numbers, 83.
Bose, D. M. Some recent theories of magnetism, 39.
Bose, Sir J. C. Unity of life, 5.
Bose, J. P. *See* Acton, H. W., and J. P. Bose.
Bose, K. *See* Ghosh, J. C., and K. Bose.
Bose, N. K. Generation of Karman's vortex-path, 85.
Bose, N. K. Stream lines of laminar and turbulent "grenzschicht," 85.
Bose, N. K. Variation of lift of a bi-plane with the angle of attack, 85.
Bose, P. K. Thiodiazines, 156, 157.
Bose, P. K., and D. C. Roy-Chaudhuri. Thiosemicarbazone series, 157.
Bose, R. D. Value of seed testing, 37.
Bose, S. K. Monocular perception of distance, 324.
Bose, S. N. Dualistic nature of the radiation field, 84.
Bose U., and H. K. Sen. Condensation of ethylcyclohexanone carboxylate, 155.
Bose-Ray, K. C. *See* Ray, P. C., and K. C. Bose-Ray.
Botany in ancient India, 224.
Brahmachari B. B. Constants of pure cow ghee, 282.
Brahmachari, B. B. Germicidal power of ethyl alcohol in spirits, 271.
Brahmachari, B. B., and N. K. Chatterjee. Food value of the nut of *trapa bispinosa*, 272.
Bromination of benzene, 148.
Bromine solution in carbon tetrachloride—Action of, on strontium hydroxide octahydrate, 131.
Broom-corn cultivation—Agricultural and industrial possibilities of, 32.
Buhariwalla, N. A. *See* Dastur, R. H., and N. A. Buhariwalla.
Bull roarer in India, 300.

Cadmium sulphide—Activity in presence of neutral chlorides, 136.
Calcium sulphide, phosphorescence of—Effect of impurities on the intensity and colour of, 137.
Cammiade, L. A. Palæolithic evolution in India, 306.
Camphor, origin of movements of—on water and other allied phenomena, 100.
Camphorquinone, action of sulphuric acid on—Constitution of the acid formed by, 156.
Capnodium on cotton—Biological and cultural characters of, 211.
Carbohydrate-nitrogen balance in radish plant, 221.
Carbon dioxide gas, refractive index of—Action of magnetic field on, 102.
Carbon tetrachloride, action on mercaptans, 150.
Carbonic acid gas, use of—in mercury interrupters, 100.
Carbonyl compounds, $\alpha\beta$—unsatuarted—Reactivity of the double bond in, 153.
Carboxylase—Enzymes of the lac insect with special reference to, 172.
Carcinoma among cattle in the Madras Presidency, 276.
Caryophyllaeus indicus—Re-description of, 191.
Cassiatora—Nyctitropic movements of cotyledons of, 219.
Cassidulidæ from the upper cretaceous rocks, 237.
Castor cake fodder, 168.
Catalytic oxidation of water. 135.
Catalytic reactions—Influence of light on, 174.
Central orbits, solution of two problems of—by the method of vectors, 97.
Cestodes and trematodes. 193.
Chaetogaster orientalis, suction of air by, 195.
Chakrabarti, S. C. Factorable continuant, 87
Chakravarti, D. N. Viscosity of sols in presence of electrolytes, 142.
Chandler A. C. Hymenolepis infections in India with its epidemiological significance, 282.
Characeæ of Bombay and Salsette Islands, 210.
Chatterjea G. C. Mortality due to tuberculosis by massive infection, 282.
Chatterjee, A. N. Some measurements of the Hos, 307.
Chatterjee, G. C., and others. *Tetrachilomastix bengalensis* Chatterjee. 188.
Chatterjee K. K. Pathology of amœbiasis, 280.
Chatterjee K. K. Unsaturated fatty acids on chyluria and lymphorrhagia of filarial origin, 280.
Chatterjee, N. *See* Choudhury, S. G., and N. Chatterjee.
Chatterjee. N. C. *See* Sen, R. N., and N. C. Chatterjee.
Chatterjee, N. K. *See* Brahmachari, B. B., and N. K. Chatterjee.
Chatterjee, N. R. *See* Chopra, R. N., and N. R. Chatterjee.
Chatterji, A. C. Absorption of colloidal solutions and of ions by freshly prepared precipitates, 140.
Chatterji, A. C. Formation of periodic precipitates, 139.
Chatterji, A. C. Peptising influence of gels on sparingly soluble substances and its importance in the formation of Liesegang rings, 139.
Chatterji, A. C. Theories of the formation of periodic precipitates, 138.
Chatterji, G. C. Intelligence tests for college freshmen, 325.
Chatterji, N. N. Deep-sea deposits from the Bay of Bengal, 240.
Chattopadhya, A. K. *See* Ray, P. R., and A. K. Chattopadhya.
Chaturvedi, H. S., and others. Formation of pure tricalcium sucrate, 169.
Chaube, R. K. Mental imagery of school children, 328.
Chaudhuri, H. *Vicia faba*, *Avena sativa* and *Helianthus annus*, 221.
Chavan. *See* Kottur and Chavan.
Chemistry : Presidential address, 105.
Chemotherapy of surra of horses and cattle, 283.
Cherian, M. C. South Indian Acarina, 202.

Chhibber, H. L. Ancient volcanoes of Burma, 240.
Chhibber, H. L. Petrography of the Indian and Burmese slags, 240.
Chhibber, H. L. Rhyolites and rhyolite tuffs of Thaton dist., 239.
Chhibber, H. L. Serpentines and the associated minerals of Henzada and Bassein districts, 239.
Chilean caliche—Cyclic processes in the manufacture of sodium nitrate from, 167.
Chloroform, action on mercaptans, 150.
Chlorophyll from Indian plants, 222.
Choice of future profession of 1013, Bengali boys, 322.
Cholera, treatment of—at the Puri Cholera Hospital, 269.
Cholera epidemics—Conception of the origin of, 268.
Chopra, R. N. Therapeutics in India, 243.
Chopra, R. N. Toxicity of mature and immature genuine spirits, 273.
Chopra, R. N. *See* Acton, H. W., and R. N. Chopra.
Chopra R. N., and K. S. Grewal. Opium addiction, 283.
Chopra, R. N., and N. R. Chatterjee. *Psoralia corylifolia* (Babchi.), 272.
Chopra, R. N., and others. Pharmacological action of conessine, 280.
Chopra, R. N., and others. *Sassurea lappa*, 272.
Choudary, K. S., and E. Yoganandam. 'Avaram' bark, 170.
Choudary, K. S., and others. Adulteration in Madras bark-tanned skins and hides, 170.
Choudhury, S. G. *See* Mukherjee, J. N., and S. G. Choudhury.
Choudhury, S. G., and A. T. Ganguli. Effect of non-electrolytes on the coagulation of ferric hydroxide sol, 142.
Choudhury, S. G., and N. Chatterjee. Effect of dilution and of non-electrolytes on the coagulation of colloids, 143.
Chowfin, W. Variation of pitch with amplitude, 98.
Chromatic emulsions, 140.
Chrome liquors—Effect of neutral salts on the basicity of, 171.
Chromoisomerism in amidines, 149.
Chronic broncho-pneumonic phthisis—Administration of calcium in, 264.
Chyluria and lymphorrhagia of filarial origin—Injections of unsaturated fatty acids on, 280.
Cinnamic acid and stilbene, photobromination of, 146.
Citral, attempts to prepare, 169.
Citrus trees in the Bombay Pres.—Gummosis of, 213.
Climatic bubo, treatment of—by protein shock, 263.
Cobaltic rubeanate, formation of, 133.
Cobra venom, action of, on heart, 281.
Coefficients in a certain trigonometric expansion, 90.
Coffee, rust of—Varietal resistance to, 212.
Cold incubator, simplified, 281.
Collapse therapy in the treatment of pulmonary tuberculosis in India, 266.
Colloidal solutions and ions—Adsorption by freshly prepared precipitates 140.
Colloids—Effect of dilution and of non-electrolytes on the coagulation of, 143.
Complement fixation test in the diagnosis of tuberculosis, 265.
Complex salts derived from *p*-nitrosodimethyl aniline and metallic chlorides, 134.
Conessine—Pharmacological action of, 280.
Conics, two, double contact of—Perspective-criterion for, 94.
Connor, F. Investigation of the filariasis problem, 270.
Consciousness, place of—in mental life, 320.
Constants of pure cow ghee, 282.
Contagious epithelioma of fowls—Vaccinia virus from the virus of, 262.
"Continuous spectrum" of hydrogen—Possibly spurious character of, 99.
Convergence of certain multiple series and integrals, 103.
Cooper, R. E. *See* Dastur, R. H., and R. E. Cooper.

Coronary circulation, physiology of, 267.
Corpse eating the winding-sheet in which it is swathed, 305.
Corvus insolens, 191.
Cotton for Khandesh—Improved type of, 225.
Cotton varieties, mixing of, 38.
Cottons, fertilization of ovules in, 36.
Coumarins—Reactivity in the double bond in, 153.
Coumaryl-4-acetic acid and its derivatives, 154.
Coupled oscillations—Experiments on harmonic motions of, 95.
Cow ghee, pure—Constants of, 282.
Crop experiments to test the influence of manuring, 31.
Cruickshank, E. W. H. Physiology of the coronary circulation, 267.
Ctenoplana indica n. sp.—Notes on, 190.
Cubic curve, special, 93.
Cucurbitaceae, fruit-rot disease of, 213.
Current electrolysis on adsorbed substances, 143.
Cyanacetic ester, condensation of, 173.
Cyclohexeneoxide, action on ammonium chloride, 148.
Cyclohexeneoxide and its hydrolysis by yeast, 167.
Cymene from ajwan oil, 169.
Cystitis—Causation of production of, 273.

Das. H., and others. Action of a solution of bromine, etc., 131.
Das, P N., and S. C. Basu. Treatment of cholera at the Puri cholera hospital, 269.
Das, T. C. Social organization of the Hos of Seraikella, 307.
Das, T. C. Terms of relationship of the Hos of Seraikella, 307.
Das-Gupta, H. C. Batrachian and reptilian remains found in the Panchet beds at Deoli, 240.
Das-Gupta, H. C. Geology of the Island of Bombay, 240.
Das-Gupta, H. C. Polyandry in the Mahabharata, 301.
Das-Gupta, P. N., and P. R. Ray. Action of alkaline ferricyanide on silver nitrate solution, etc., 132.
Dass, B. *See* Krishna, S., and B. Dass.
Dastur, R. H., and N. A. Buhariwalla. Chlorophyll from Indian plants, 222.
Dastur, R. H., and R. E. Cooper. Water content and photosynthesis, 218.
Datta, A. K. Knowledge of the purpose in the marking of compositions, 322.
Datta, A. K. Reliability of essay marks, 323.
Datta, H. Fundamental magnitudes of the second order expressed separately in terms of those of the first order, 96.
Datta, H. Problem of rolling motion, 96.
Datta, H. K. *Shorea robasta* forest of Bhowal, 224.
Datta, K. L. *See* Sen, H. K., and K. L. Datta.
Datta, M. N. *Echinorhynchus* sp., 194.
Datta, S. Reversal of bands, 74.
Datta, S., and S. C. Sen. Ionisation potential of elements showing flame lines, 74.
David, J. C., and others. Pharmacological action of conessine, 280.
Davies, L. M. Genus *Dictyoconus*, 241.
De, P., and others. *Sassurea lappa*, 272.
Debarya from South India—Three species of, 210.
Deep-sea deposits from the Bay of Bengal, 240.
Dennehy, H. G. *Kani puja* of the Mikirs of Assam, 306.
Dennehy, H. G. Naga medicine, 306.
Des Raj and others. Effect of time on the gelating sols, 140.
Dey, B. B. Oil from the seeds of *Asteriastigma Macrocarpa*, 162.
Dey, B. B. *See* Venkataraman, A. A., and B. B. Dey.
Dhar, N. R. Change of electric conductivity of hydrophobe and hydrophile colloids on ageing, 142.

Dhavale, B. B., and B. N. Pal. Effect of neutral salts on chrome liquors, 171.
Diamine, acetylation of 164.
Diaryl *p*-aminobenzamidines, syntheses of, 149.
Diazonium salts, interaction with acetyl cycloketones, 150.
Diazotisation and nitration of aromatic amino compounds, 149.
Dictyoconus—Indian species of, 241.
Dielectric constant, effect of—on the adsorbability of ions, 95.
Dilatometric investigations of enzyme action, 171.
Dive, G. H., and P. N. Basu. Treatment of climatic bubo by protein shock, 263.
Diphenylene-1 : 4 : 5-oxydisulphide—Synthesis of, 159.
Dithio-ethers, formation and properties of, 174.
Dithio-ketones, formation and properties of, 174.
Dixit, S. C. Characeæ of Bombay and Salsette Islands, 210.
Dodd, S. C. International group mental tests, 327.
Double contact of two conics—Perspective-criterion for, 94.
Double sulphates of the copper magnesium group and the sulphonium bases, 131.
Dream of an ascetic disciple, 319.
Drinking waters—Ferro-solvency of, 271.
Dropsy epidemic—Causation of, 277.
Dunnicliff, H. B. *See* Singh, B., and H. B. Dunnicliff, H. B.
Dunnicliff. H. B. *See* Soni, C. L., and H. B. Dunnicliff.
Dunnicliff, H. B., and others. Action of a solution of bromine, etc., 131.
Dunnicliff, H. B. and others. System $(NH_4)_2\ SO_4$—H_2SO_4—C_2H_5OH, 135.
Dust storms, electricity produced by, 77.
Dutt, A. T., and others. *Sassurea lappa*, 272.
Dutt, J. C., and D. Sarkar. Speed and quality in Bengali handwriting, 322.
Dutt, G. R. Aphids and lady-bird beetles, 35.
Dyes, effect of, on the lustre of silk fabrics, 164.
Dysdercus cingulatus Fb. (Rhynchota) and *Aulacophora abdominalis* Fb. (Coleop.), 198.

Echinorhynchus sp., 194.
Edwards, J. T. Chemotherapy of surra of horses and cattle, 283.
Egyptian cotton in Sind, 36.
Elastic plate, stress and strain in—under the action of a couple at the corner, 95.
Electric conductivity of hydrophobe and hydrophile colloids on ageing—Change of, 142.
Electricity produced by dust storms, 77.
Electrolytes, mixtures of—Measurement of charge, 144.
Electron sub-groups—Smith-Stoner's classification of, and co-valency conception as applied to simple and co-ordination compounds, 135.
Eleusine coracana—Purple pigmentation in, 224.
Ellipticity of light, measurements of—reflected at the free surfaces of liquids at the Brewsterian angle, 101.
Embiadine—External morphology and anatomy of, 198.
Emil Fischer, so-called phenyl-sulphocarbazine of, 159.
Entomostraca, fresh water, of Lahore, 198.
Enzyme action—Dilatometric investigations of, 171.
Enzyme solution, method for concentrating, 165.
Enzymes of the lac insect with special reference to carboxylase, 172.
Epistylis Ehr.—Four new species of, 189.
Error in the ages of Bengali boys, 323.
Essay marks—Reliability of, 323.
Estimation of—SOOH and Fe‴, 164.
Ethers, preparation of—by the use of solid catalysts, 147.

Ethyl alcohol in spirits—Germicidal power of, 271.
Ethylcyclohexanone carboxylate—condensation of, 155.
Eugenia—Behaviour of the radicle and plumule of, 219.
Euphorbia tibetica Boiss, 216.
Eutyphoeus waltoni, reproductive process of, 195.
Evaluation of special persymmetrics, 91.

Factitious spirits—Toxicity of, 273.
Factorable continuant, 87.
Fauna of the Bombay shore, 206.
Fauna of the Kangra valley, 207.
Ferns as an article of food in Rangpur district, 303.
Ferric chloride in alcoholic solutions—Photochemical decomposition of, 145.
Ferric hydroxide sol—Effect of non-electrolytes on the coagulation of, 142.
Ferro-solvency of drinking waters, 271.
Filarial and lymphatic obstruction—Cause and aetiology of, 279.
Filariasis problem—Investigation of, 270.
"Fine structure" of lines of hydrogen—Possibly spurious character of, 99.
Fish, manuscript drawings of, 204.
Fish, vitality of, 204.
Fishing implement from the Kangra valley, 300.
Flagellates, intestinal—Account of, 188.
Flagellates and rhizopods from Kashmir, 189.
Flow, turbulent, in earthern channels—Hydrodynamical problems connected with, 87.
Forgetting and amnesia, 323.
Fossil wood from the Lalmai range in Comillah, 240.
Fossil wood from the Utatur cretaceous, 237.
Fowler, G. J. *See* Mulany, H. M., and G. J. Fowler.
Fox, C. J. J., and C. L. Mankodi. Hydrolysis of ammonium carbonate solutions, 141.
Fresnel's convection coefficient in general relativity, 84.
Frimodt-Moller, C. Application of our knowledge of tuberculosis to Indian conditions, 264.
Frimodt-Moller, C. Sanocrysin treatment of tuberculosis, 265.
Frog marriage in Assam, 306.
Frogs and toads from the Punjab, 204.
Fruit-rot disease of cultivated cucurbitaceae, 213.
Fundamental magnitudes of the second order of a surface being expressed separately in terms of those of the first order, 96.

Gajendragad, N. G., and others. Preparation of ethers by the use of solid catalysts, 147.
Gall formation on the roots of mustard, 213.
Ganguli, A. T. *See* Chaudhury, S. G., and A. T. Ganguly.
Gastalt-theorie, 325.
Gastropod molluscs from Kangra valley, 197.
Gaurdas, T. B. Quincke's method of finding surface tension, 98.
Gelating sols, effect of time on, 140.
Gels, peptising influence on sparingly soluble substances, its i mportance in forming Liesegang rings, 139.
Geometrical interpretation of the invariants of a pair of bilinear forms, 98.
Geology of the Island of Bombay, 240.
Geraniol, attempts to prepare, 169.
Germicidal power of ethylalcohol in spirits, 271.
Ghee—Method of detecting adulteration in, 168.
Ghose, S. L. Sub-aerial blue-green algae of Rangoon, 209.
Ghosh, D. N., and H. E. Watson. Interfacial tension, 147.

Ghosh, E. Four new species of *Epistylis* Ehr., 189.
Ghosh, H. Treatment of asthma, 281.
Ghosh, J. C., and J. Mukherjee. Absorption of light in the ultraviolet, 145.
Ghosh, J. C., and K. Bose. Photobromination of tartaric acid, 145.
Ghosh, J. C., and R. M. Purkayastha. Photobromination of cinnamic acid and stilbene, 146.
Ghosh, K. S. Behaviorist standpoint, 321.
Ghosh, N. N., and others. Pharmacological action of conessine, 280.
Ghosh, P. N., and P. C. Mahanti. Action of magnetic field on the refractive index of carbon dioxide gas, 102.
Ghosh, R. N. Acoustics of the pianoforte, 97.
Ghosh, R. N., and B. Majumdar. Efficiency of musical instruments, 97.
Ghosh, S. Adsorption and coagulation of stannic hydroxide sol, 144.
Ghosh, S., and others. *Sassurea lappa*, 272.
Ghosh, S. K. *See* Sen, H. K., and S. K. Ghosh.
Ginkgo biloba—Funnel-like leaves in, 215.
Gold fish, development of, 203.
Gopal, K. *See* Srivastava, B. P., and K. Gopal.
Gorakshanātha, cult of, in Rangpur, 302.
Goswami, B. K. *See* Ray, P. R., and B. K. Goswami.
Goswami, M. Catalytic oxidation of water, 135.
Gram-negative non-lactose-fermenting bacilli in the causation of bacillary dysentery in Bengal, 269.
Granitic and gneissic rocks—Petrological notes on, 238.
Grewal K. S. *See* Chopra R. N., and K. S. Grewal.
Guha, B. Human crania excavated at Adittanallur, 307.
Guha, B. Matrimonial institutions of the Syntengs, 307.
Guha, P. C., and H. K. Banerjee. Benzidine inversion in bis-hydrazo-compounds, 159.
Guha, P. C., and H. K. Banerjee. So-called phenyl-sulphocarbazine of Emil Fischer, 159.
Guha, P. C., and P. C. Sen. Action of urea upon semi- and thiosemi-carbazides, 157.
Guha, P. C., and S. C. Guha. Action of *ortho*diketones on methyl-dithio-carbazinate, 158.
Guha, P. C., and S. C. Guha. Attempt towards the synthesis of *o*-thiol-phenyl-hydrazine : Synthesis of diphenylene—1 : 4 : 5-oxydisulphide, 159.
Guha, P. C., and S. C. Guha. Syntheses in the thiobiazole and oxybiazole series, 158.
Guha, S. C. *See* Guha, P. C., and S. C. Guha.
Gulati, A. N. *See* Bhatia, B. L., and A. N. Gulati.
Gummosis of citrus trees in the Bombay Pres., 213.
Gupta, B. L. Electricity produced by dust storms, 77.
Gupta, B. L. Hot wire anemometry, 77.
Gupta, J. C., and others. Pharmacological action of conessine, 280.
Guthrie, A., and others. Adulteration in Madras bark-tanned skins and hides, 170.
Gypsum in the reclamation of bara, 35.

Hair, sanctity of—in South India, 301.
Halides, estimation of—in a mixture, 134.
Hamid, C. A. Fresh water polyzoa from Lahore, 197.
Hamid, M. A. Cyclic processes in the manufacture of sodium nitrate from Chilean caliche, 167.
Hamid, M. A. Identification of solid phases, 147.
Hamid, M. A. Phase reactions at the invariant points, 146.
Hasan, K. H. Acetylation of diamine, 164.
Hasan, K. H. Formation of quinicine, 170.

Hasan, K. H. *See* Bhate, S. R., and K. H. Hasan.
Helianthus annus—Influence of light and darkness upon, 221.
Helminth parasites of *Ophiocephalus*, 193.
Henderson, J. M., and others. Tumours caused by intraperitoneal inoculation of *B. lepra murium*, 264.
Hexamethylene tetramine, action of—upon solutions of salts of the elements of group III, etc., 133.
Hingston, C. A. F., and A. Lakshmanaswamy. Puerperal eclampsia, 278.
Hingston, C. A. F., and A. Lakshmanaswamy. Puerperal sepsis, 277.
Hiralal. Untouchables among animals and plants, 301.
Ho hut-designs, 308.
Holarrhena antidysenterica, alkaloid of—Pharmacological action of, 280.
Hoon, R. C., and others. System $(NH_4)_2SO_4$—H_2SO_4—C_2H_5OH, 135.
Hora, S. L. Fauna of the Kangra valley, 207.
Hora, S. L. Fishing implement from the Kangra valley, 300.
Hora, S. L. Manuscript drawings of fish in the library of the Asiatic Society of Bengal, 204.
Hora, S. L. Mayfly swarms, 199.
Hora, S. L. *Rana afghana* in W. Himalayas, 205.
Hora, S. L. Use of fishes for control of mosquitoes, 266.
Hos—Some measurements of the, 307.
Hos of Seraikella—Social organization of, 307.
Hos of Seraikella—Terms of relationship of, 307.
Hot wire anemometry, 77.
Howard, A. Eradication *of Kans*, 38.
Howard, A. Feeding value of straw-chaff, 38.
Howard, A., and S. C. Talesara. Mixing of cotton varieties, 38.
Human crania excavated at Adittanallur, 307.
Human sacrifice among the Santals, 304.
Husain, T. *See* Nath, V., and T. Husain.
Hussain, M. A. *Aulacophora abdominalis* Fb. and *Dysdercus cingulatus* Fb., 198.
Hutton, J. H. Anthropology and administration, 285.
Hydra of the Bombay Island, 190.
Hydrazine with metallic sulphites and nitrites, 130.
Hydrocarbons, aromatic—Iodination of, 148.
Hydrodynamical problems connected with turbulent flow in earthern channels, 87.
Hydro-electric power plant at Mandi, 241.
Hydrogen, "fine structure" of lines and "continuous spectrum" of—Possibly spurious character of, 99.
Hydrogen sulphide—Action on lead peroxide, 134.
Hydrogenation of "Nag-kesar" (*Mesua ferrea*) oil, 163.
Hydrolysis of ammonium carbonate solutions, 141.
Hydrolytic adsorption, nature of, 144.
Hydrophobe and hydrophile colloids—Change of electric conductivity of, 142.
Hygroscopicity of aqueous crystals—Factors governing the, 138.
Hymenolepis infections in India—Epidemiological significance of, 282.

Ignition points of sulphur and phosphorus, 130.
Indian and Burmese slags—Petrography of, 240.
Indian cattle, capacities of—for food consumption and digestion, 27.
Indian folk-belief, 305.
Indian fossil conifers—Petrified cones of, 215.
Indian frogs, toads, earthworms and cockroaches—Parasitic ciliates from, 188.
Indian grains—Studies in the proteins of, 165.
Indian microdrili, geographical distribution of, 195.
Indian plants, chlorophyll from, 222.

Indian plants—Urease content of seeds of, 165.
Indian species of Blanckenhorn's genus *Dictyoconus*, 241.
Indian ticks of the family of Ixodidae, 202.
Indol and acridine derivatives containing an α-pyrone ring, 154.
Inene, 161.
Inferiority complex, 322.
Inorganic salts and organic crystals—Indices of refraction of, in aqueous solution, 136.
Insane conduct—Interpretation of, 321.
Insects, small—Method of determining temperature of, 274.
Intelligence, general—Single tests as measures of, 326.
Intelligence tests for college freshmen, 325.
International group mental tests, 327.
Invariants of a pair of bilinear forms—Geometrical interpretation of, 98.
Invertase, studies on, 165.
Iodination of aromatic hydrocarbons, 148.
Iodine in soils, estimation of, 167.
Ionisation potential of elements showing flame lines, 74.
Ionisation potential and periodic classification, 75.
Ionisation potentials and atomic sizes, 75.
Ions, absorbability of—Effect of the dielectric constant on, 95.
Ions, independent activity of, 143.
Ions and colloidal solutions—Adsorption by freshly prepared precipitates, 140.
Iron, quantitative separation of—from manganese, zinc, nickel and cobalt, 133.
Iron slags from the Seraikela State, 308.
Irrigation water and rainfall in the soil, 35.
Iso-erucic acid, 156.
Iso-quinoline alkaloids—Synthetical experiments on, 155.
Iso-vanillic acid, preparation of, 154.
Ixalactis, actiniarian genus—Systematic position of, 190.
Iyengar, B. K. T. *See* Rao M. G. S., and B. K. Iyengar.
Iyengar, K. S. K. Convergence of certain multiple series and integrals, 103.
Iyengar, M. O. P. Debarya from South India, 210.
Iyengar, M. S. *See* Rao, M. G. S., and M. S. Iyengar.
Iyer, L. K. A. Sectarian marks of Hindus in South India, 300.
Iyer, L. K. A. Totemism in South India, 301.
Iyer, T. S. Lactose-fermenters by serological methods, 262.

Jadhav, G. V. *See* Naik, K. G., and G. V. Jadhav.
Jatkar, S. K. K., and others. Preparation of ethers by the use of solid catalysts, 147.
Jelly-fishes of the Indian seas, 190.
John, C. M. *Solanum melongena*, 216.
Josephus problem and its extension, 94.
Joshi, N. V. Economical method of manuring with sunn hemp, 33.
Junction potential, annulment by saturated potassium chloride, 143.

Ka doublet, irregularity of—in the elements of lower atomic numbers, 83.
Kala-azar and syphilis—Globulins in, 279.
Kamat, M. N. Gummosis of citrus trees in the Bombay Pres., 213.
Kani puja of the Mikirs of Assam, 306.
Kans (*Saccharum spontaneum L.*)—Eradication of, 38.
Karandikar, K. R. *See* Awati, P. R., and K. R. Karandikar.
Karman's vortex-path—Generation of, 85.
Kashyap, S. R. *Euphorbia tibetica* Boiss, 216.
Ketones, condensation of, 153.
Khan, H. Development of gold fish, 203.
Khan, H. Vitality of fish, 204.

Khan, S. *See* Luthra, J. C., and S. Khan.
Khastgir, K. Solution of two problems of central orbits by the method of vectors, 97.
Khastgir, S. R. Barkla-effect with scattered X-radiation, 101.
Kichlu, P. K. Series relation in the spectrum of copper, 79.
Kichlu, P. K. Spectrum of nickel, 78.
Kinæsthetic presentation—Retention by, 326.
Kinetic theory to surface films, on the application of, 137.
Kinetics of the decomposition of mercuric formate, 147.
Knowledge of the purpose in the marking of compositions, 322.
Koch's vibrio, healthy carriers of—Specific agglutinins in the blood of, 268.
Kohlschutter's silver sol, 171.
Kongu Nad—Poo-nonbu in, 306.
Kothari, C. J., and H. E. Watson. Photochemical oxidation of toluene and benzaldehyde, 147.
Kottur and Chavan. Correlation between yield and some prominent characters in *Andropogon sorghum*, 32.
Krishna, S., and B. Dass. Volumetric estimation of -SOOH in sulphinic acids, 164.
Krishna, S. and H. Singh. Estimation of -SOOH and Fe‴, 164.
Krishna, S., and S. Singh. Action of chloroform and carbon tetrachloride on mercaptans, 150.
Krishnamurthy, P. V. *See* Varma, P. S., and P. V. Krishnamurthy.
Krishnamurti, P. *See* Seshadri, T. R., and P. Krishnamurti.
Krishnamurti, S. Activity of cadmium sulphide in presence of neutral chlorides, 136.
Kumar, K. *See* Singh, B. N., and K. Kumar.
Kumar, K. K. *See* Mukherjee, J. N., and K. K. Kumar.
Kumar, R. R. McDougall's theory of laughter at the ludicrous, 326.
Kyanite from Nellore, 237.

Lac cultivation—Experimental control of sex ratio and its bearing on, 35.
Lac insect, enzymes of—with special reference to carboxylase, 172.
Lactometer readings for temperature—Correction of, 171.
Lactose-fermenters by serological methods—Classification of, 262.
Lakshmanaswamy, A. *See* Hingston, C. A. F., and A. Lakshmanaswamy.
Lal, K., and others. Action of a solution of bromine, etc., 131.
Lal, M. Use of gypsum in the reclamation of bara, 35.
Laminar and turbulent "grenzschicht"—Stream lines of, 85.
Landeman, E., and others. Tumours caused by intraperitoneal inoculation of *B. lepra murium*, 264.
Laughter at the ludicrous—McDougall's theory of, 326.
Law, S. C. Birds of the district of 24-Parganas, 205.
Lead peroxide—Action of hydrogen sulphide on, 134.
Leaves, respiration of—Influence of sugar on, 223.
Leguminous plants—Root nodule organism of, 210.
Leishman-Donovan bodies, method of staining—in the tissues, 270.
Leishmania tropica—Oriental sore in man by flagellate culture of, 275.
Lele, S. H. *Ophiocephalus punctatus* Bloch., 203.
Leprosy—Factors which influence the incidence of, 282.
Liesegang rings, importance of peptising influence of gels in the formation of, 139.
Light, absorption in the ultraviolet, 145.
Light, ellipticity of—reflected at the free surfaces of liquids at the Brewsterian angle, 101.
Light, influence of—on catalytic reactions, 174.
Light, scattering of—by gaseous mixtures at high pressures, 101.
Limaye, D. B. Coumaryl-4-acetic acid and its derivatives, 154.
Limnœa luteola Lamarck—Breeding habits and fecundity of, 196.
Liquids, surface reflectivity of, 138.

Love of music, 319.
Luciola gorhami, eggs of, 200.
Luciola gorhami,—Life history of, 201.
Lunar periodicity, beliefs in—in animals and plants, 306.
Luthra, J. C., and B. L. Batra. Potato tubers, 218.
Luthra, J. C., and R. Singh. Studies on the growth of wheat plants and correlations between certain wheat characters, etc., 36.
Luthra, J. C., and S. Khan. Fertilization of ovules in various cottons, 36.
Lymphorrhagia and chyluria of filarial origin—Infection of unsaturated fatty acids on, 280.

McDougall's theory of laughter at the ludicrous, 326.
Macmahon, P. S., and M. R. Nayar. Kohlschutter's silver sol, 171.
Madras bark-tanned skins and hides—Adulteration in, 170.
Magnetic field, action of—on the refractive index of carbon dioxide gas, 102.
Magnetism, recent theories on, 39.
Mahanti, P. C. *See* Ghosh, P. N., and P. C. Mahanti.
Mahdihassan, S. Experimental control of sex ratio and its bearing on lac cultivation, 35.
'Mahisakshi gugul' (Balsomodendron Mukul), 162.
Maitra, G. C. *See* Tomb, J. W., and G. C. Maitra.
Maity, H. Demonstration of Weber's law in the field of visual brightness, 325.
Majumdar, B. *See* Ghosh, R. N., and B. Majumdar.
Majumdar, G. P. Botany in ancient India, 224.
Majumdar, G. P. Shoot-axis and primary root, 216.
Majumdar, K. *See* Sur, N. K., and K. Majumdar.
Majumdar, S. *See* Sen, H. K., and S. Majumdar.
Mankodi, C. L. *See* Fox, C. J. J., and C. L. Mankodi.
Manures—Principles governing the application of, 168.
Manuring a crop, effect of—on the vegetative and reproductive capacity of the seed, 31.
Manuring with sunn hemp—Economical method of, 33.
Mansuri, Q. A. Estimation of halides in a mixture, 134.
Maternity and child welfare, 270.
Mathematics and physics : Presidential address, 39.
Mathur, S. B. L. *See* Mohammad, W., and S. B. L. Mathur.
Mayfly swarms, on the emergence of, 199.
Mazumdar, S. K. *See* Acton, H. W., and S. K. Mazumdar.
Mechanical gravity filters, efficiency of—for purification of water, 271.
Mehra, H. R. *Chætogaster orientalis*, 195.
Mehra, H. R. Reproduction of the naididæ, 195.
Mehta, D. R. Life history of *Luciola gorhami*, 201.
Mehta, D. R. *See* Nath, V., and D. R. Mehta.
Mehta, K. C. *Puccinia graminis* Pers., 214.
Mehta, K. C. *Puccinia triticina* Eriks and Honn., 214.
Mehta, S. M. *See* Meldrum, A. N., and S. M. Mehta.
Meldrum, A. N., and S. M. Mehta. Titration of acids by a solution of sodium borate, 134.
Menon, C. K. *See* Varma, P. S., and C. K. Menon.
Menon, K. R. *Ctenoplana indica* n. sp., 190.
Menon, K. R. Systematic position of actiniarian genus *Ixalactis*, 190.
Menon, S. S. Psychodynamics, 319.
Mental imagery of school children—Experimental tests in, 328.
Mental life—Place of consciousness in, 320.
Menthol, attempts to prepare, 169.
Mercaptans—Action of chloroform and carbon tetrachloride on, 150.
Mercuric formate, kinetics of the decomposition of, 147.
Mercury, magnesium, tin and aluminium—Determination of the equivalent weights of, by the synthesis of their bromides, 132.

Mercury, white precipitates of—Constitution of infusible and fusible, 130.
Mercury interrupters—Use of carbonic acid gas in, 100.
Metals of the second group—Spectra of, 81.
Methyldithiocarbazinate—Action of *ortho*diketones on, 158.
Microchemical method for locating urease within a cell, 166.
Microflora of activated sludge—Sulphur oxidation on, 34.
Mikirs of Assam – *Kani-puja* of, 306.
Mills, J. P. Some objects of anthropology, 300.
Mimosa—Anatomical and physiological investigations on, 217.
Mirchandani, B. J., and J. L. Simonsen. *Iso*-erucic acid, 156.
Mitra, A. K. *See* Neogi, P., and A. K. Mitra.
Mitra, A. N., and others. *Tetrachilomastix bengalensis* Chatterjee, 188.
Mitra, M. Fruit-rot disease of cultivated cucurbitaceæ, 213.
Mitra, M. Gall formation on the roots of mustard, 213.
Mitra, N. G., and others—Surface reflectivity of liquids, 138.
Mitra, P. Ho hut-designs, 308.
Mitra, P. Iron slags from the Seraikela State, 308.
Mitra, P. Stone implements from the Seraikela State, 307.
Mitra, S. C. Bengali women's charms for stopping storms, 305.
Mitra, S. C. Cult of Gorakshanātha in Rangpur district, 302.
Mitra, S. C. Ferns as an article of food in Rangpur district, 303.
Mitra, S. C. Human sacrifice among the Santals, 304.
Mitra, S. C. Indian folk-belief, 305.
Mitra, S. C. Legends about the origin of the place-name, Rangpur, 303.
Mitra, S. C. Perception of forms in indirect vision, 324.
Mitra, S. C. Rangpuri superstition, 302.
Mitra, S. C. Satyapir legend in Santali guise, 304.
Mitra, S. C. Self-immolation for propitiating a god, 304.
Miter, P. C., and N. Palit. On inene, 161.
Mitter, P. C., and N. Palit. Preparation of *iso*vanillic acid, 154.
Mitter, R. P. *See* Mukherjee, J. N., and R. P. Mitter.
Moghe, M. A. Re-description of *Caryophyllaeus indicus*, 191.
Mohammad, W., and S. B. L. Mathur. Fine structure of spectrum lines, 98.
'Mohwa' flowers, storage of, 169.
Mole drainage, 35.
Monocular perception of distance, 324.
Mookherji, K. C. Space limen in relation to the axis of rotation in the right arm, 328.
Moses, S. T. *Ostrea madrasensis*, 196.
Moses, S. T. Sanctity of hair in South India, 301.
Moses, S. T. Tortoise in Indian life and religion, 301.
Mosquitoes, control of—Use of fishes for, 266.
Mucilage exudation of *Sorghum vulgare*, 217.
Muir E. Incidence of leprosy, 282.
Muir, E., and others. Tumours caused by intraperitoneal inoculation of *B. lepra murium*, 264.
Mukerjee, H. C. *See* Bannerjee, S. K., and H. C. Mukerjee.
Mukerjee, K. C., and others. Formation of pure tricalcium sucrate, 169.
Mukerjee, S. External morphology and anatomy of a new species of embiadine, 198.
Mukerji, D. *Synemosyna* Hentz, 202.
Mukherjee, G. Hydrolysis of anilides of 2 : 3–oxynaphthoic acid, 152.
Mukherjee, G. Hydrogenation of "Nag-kesar" (*Mesua ferrea*) oil, 163.
Mukherjee, J. *See* Ghosh, J. C., and J. Mukherjee.
Mukherjee, J. N., and J. K. Basu. Nature of hydrolytic adsorption, 144.
Mukherjee, J. N., and K. K. Kumar. Independent activity of ions and the annulment junction potential by saturated potassium chloride, 143.
Mukherjee, J. N., and R. P. Mitter. Partition coefficient of organic acids between benzene and water as affected by neutral electrolytes, 143.

Mukherjee, J. N., and S. G. Choudhury. Dielectric constant on the adsorbability of ions, 95.
Mukherjee, J. N., and S. Ray-Chaudhury. Measurement of charge with mixtures of electrolytes, 144.
Mulany, H M., and E. R. Watson. Attempts to prepare citral, geraniol, menthol, etc., 169.
Mulany, H. M., and G. J. Fowler. Castor cake fodder, 168.
Multiple series and integrals—Convergence of certain, 103.
Musical instruments, efficiency of, 97.
Mustard, roots of—Gall formation on, 213.
Mysore-American cotton, yielding power of a strain of—compared with that of Cambodia and Dhawar-American, 32.
Mysticism and psychology, 327.

Nag, N. C. Influence of light on catalytic reactions, 174.
Naga medicine, 306.
"Nag-kesar" (*Mesua ferrea*) oil—Hydrogenation of, 163.
Naididæ, reproduction of, 195.
Naidu, D. S. 'Mahisakshi gugul' (Balsomodendron Mukul), 162.
Naik, K. G., and G. V. Jadhav. Interaction of sulphur dichloride with substances containing reactive methylene group, 172.
Naik, K. G., and V. N. Bhat. Interaction of sulphur monochloride with organic compounds containing the reactive methylene group, 174.
Naik, K. G., and Y. N. Bhat. Condensation of cyanacetic ester with aryl and alkyl amines, 173.
Naik, K. G., and Y. N. Bhat. Interaction of sulphur monochloride with substances containing the reactive methylene group, 173.
Nair, S. U., and J. L. Simonsen. Derivatives of acenaphthpyridine, 156.
Naphthalene, nitration of, 148.
Narayan, B. *See* Varma, P. S., and B. Narayan.
Narayana, N., and R. V. Norris. Proteins of Indian grains, 165.
Nath, B. V., and M. Suryanarayana. Effect of manuring a crop on the vegetative and reproductive capacity of the seed, 31.
Nath, D. *See* Anand, C., and D. Nath.
Nath, V. Eggs of spiders, 200.
Nath, V., and D. R. Mehta. Eggs of *Luciola gorhami*, 200.
Nath, V., and T. Husain. Eggs of *Scolopendra*, 201.
Nayar, M. R. *See* Macmahon, P. S., and M. R. Nayar.
"Neem" oil—Bitter principle of, 162.
Nehru, S. S. Attempt to introduce and acclimatise *Andropogon sorghum* var. *Technicus* with seed introduced from N.-W. Italy, etc. 32.
Neogi, P., and A. K. Mitra. A new scaly variety of aluminium hydroxide, 160.
Neon lamp—Oscillations of audible frequency produced in, 100.
Neon tube discharge, 99.
Neurasthenia, tropical, 278.
Neutral salts, effect of—on the basicity of chrome liquors, 171.
Nickel wire, resistance of—beyond the elastic limits, 95.
Nigam, S. *See* Batham, H. N., and S. Nigam.
Nigudkar, K. D. Photochemical decomposition of ferric chloride in alcoholic solutions, 145.
Nishina, Y., and B. Ray. Relative intensity of X-ray lines, 83.
Nitrate content of soils—Seasonal variations of, 33.
Nitration and diazotisation of aromatic amino-compounds, 149.
Nitration of naphthalene, 148.
Nitrifying power of a soil—Varying concentration of ammonia on, 33.
Nitro-acids of the β-resorcylic acid series. 151.
p-Nitrosodimethyl aniline and metallic chlorides—Complex salts derived from, 134.
Niyogy, S. C. Preparation of 4-acetylamino-3-chlorophenyl stibinate of sodium, 163.

Noronha, F. Interpretation of insane conduct, 321.
Norris, R. V. *See* Narayan, N., and R. V. Norris.
Norris, R. V. *See* Patwardhan, V. N., and R. V. Norris.
Norris, R. V. *See* Ramaswami, C. V., and R. V. Norris.
Norris, R. V. *See* Rao, D. A. R., and R. V. Norris.
Norris, R. V. *See* Sastri, B. N., and R. V. Norris.
Norris, R. V. *See* Thakore, A. K., and R. V. Norris.
Notothylas indica Kashyap, 215.
Nyctitropic movements of cotyledons of *Cassia tora*, 219.

Oil fields of Burma, 227.
Oligochætes and polychætes—Monocystids of, 189.
Oligotoma, a new species of, from Peradenyia, 198.
Oncis martensi, development of, 196.
Ophiocephalus, helminth parasites of, 193.
Ophiocephalus punctatus Bloch., 203.
Ophioglossum aitchisoni D'Almeida—Anatomy of, 215.
Ophioglossum vulgatum L.—Anatomy of, 215.
Opium addiction, 283.
Optical rotatory power—Influence of sulphur atom on, 160.
Organic acids between benzene and water as affected by neutral electrolytes—Partition coefficient of, 143.
Organic crystals and inorganic salts—Indices of refraction of, in aqueous solution, 136.
Organo-sols, some special features of, 142.
Oriental sore in man by flagellate culture of *Leishmania tropica*, 275
Oscillations of audible frequency produced in a neon lamp, 100.
Ostrea cucullata, development of, 195.
Ostrea madrasensis, anatomy and life history of, 196.
Ova, origin of yolk in, 200.
Ovules, fertilization of—in various cottons, 36.
Oxybiazole and thiobiazole—Syntheses in, 158.
2 : 3-Oxynaphthoic acid, hydrolysis of anilides of, 152.

Paddy, root development of, 38.
Pai, M. K. Aspects of artificial pneumothorax therapy in India, 266.
Pai, M. K., and K. V. Rau. Complement fixation test in the diagnosis of tuberculosis, 265.
Pal, B. N. *See* Dhavale, B. B., and B. N. Pal.
Pal, G. Vocabulary study of two children, 324.
Palaeolithic evolution in India, 306.
Palit, N. *See* Mitter, P. C., and N. Palit.
Pande, S. K. *Notothylas indica* Kashyap, 215.
Pande, S. K. *Riccia robusta* Kashyap, 214.
Pandit, C. G. Vaccinia virus from the virus of contagious epithelioma of fowls, 262.
Panicker, K. G. *See* Varma P. S., and K. G. Panicker.
Panja, G. Oriental sore in man by flagellate culture of *Leishmania tropica*, 275.
Panja, G., and K. Banerjee. Causation of production of cystitis, 273.
Papain, extraction from papaya, 168.
Paranjpe, G. R. Oscillations of audible frequency produced in a neon lamp, 100.
Paranjpe, G. R., and H. D. Tendulkar. Use of carbonic acid gas in mercury interrupters, 100.
Parasitism among protozoa, 189.
Parija, P. Ricinus fruits, 218.
Parthenogenesis in cotton, 224.
Partition co-efficient of organic acids between benzene and water as affected by neutral electrolytes, 143.

Patel, P. T. Collapse therapy in the treatment of pulmonary tuberculosis in India, 266.
Patwardhan, V. N., and R. V. Norris. Amylase from *Andropogom sorghum*, 166.
Peptising influence of gels on sparingly soluble substances and its importance in the formation of Liesegang rings, 139.
Perception of forms in indirect vision, 324.
Periodic precipitates, the formation of, 139.
Periodic precipitates, theories of the formation of, 138.
Perspective-criterion for the double contact of two conics, 94.
Persymmetric determinants—Simplification of, 89.
Persymmatrics, special—Evaluation of, 91.
Petrography of the Indian and Burmese slags, 240.
Phase reactions at the invariant points, 146.
Phenyl-sulphocarbazine—Constitution and mechanism of formation of, 159.
Phenylated ureas, synthesis of, 150.
Phosphorescence of calcium sulphide—Effect of impurities on the intensity and colour of, 137.
Photobromination of cinnamic acid and stilbene, 146.
Photobromination of tartaric acid, 145.
Photochemical decomposition of ferric chloride in alcoholic solutions, 145.
Photochemical oxidation of toluene and benzaldehyde, 147.
Photo-sols, studies in, 141.
Photosynthesis and water content—Relation between, 218.
Pianoforte, acoustics of, 97.
Pigeon heavily infested with tape worms, 193.
Pinus longifolia, microsporogenesis in, 215.
Pitch, variation of—with amplitude. 98.
Plant organs—Carbohydrate analysis in, 220.
Poisson's ratio tester, 96.
Polyandry in the Mahabharata, 301.
Polychætes and oligochætes—Monocystids of, 189.
Polyzoa, fresh water, from Lahore, 197.
Poo-nonbu in Kongu Nad, 306.
Potato tubers, physiology of, 218.
Potatoes-Super and its effect on, 34.
Prakash Chandra and others. Factors governing the hygroscopicity of aqueous crystal, 138.
Prasad, Mata, and S. D. Bhave. Viscosity of sodium and potassium amalgams, 141.
Prayag, S. H. Cotton for Khandesh, 225.
Presidential address : General, 5.
Projection of spectra, 95.
Protein shock—Treatment of climatic bubo by, 263.
Protozoa, parasitism among, 189.
Psoralia corylifolia (Babchi.), 272.
Psychodynamics, 319.
Psychogalvanic and psycho-circulatory reflexes of sense stimulation, 327.
Psychology of advertisement, 324.
Psychology of dreams in Upanishads, 320.
Psychology and the school text-book, 323.
Puccinia graminis Pers.—Infection histology of, 214.
Puccinia graminis Pers.—Morphological characters of, 214.
Puccinia triticina (Dispersa) Eriks and Honn., 214.
Puerperal eclampsia, 278.
Puerperal sepsis, 277.
Pulmonary tuberculosis in India—Collapse therapy in the treatment of, 266.
Puri, A. N. Hypothesis of " unfree water " in soils, 37.
Puri, A. N., and B. M. Amin. Mechanical analysis of soils, 37.

Purkayastha, R. M. *See* Ghosh, J. C., and R. M. Purkayastha.
α-Pyridino-acenophthenequinone, 155.

Quantitative separation of iron from manganese, zinc, nickel and cobalt, 133.
Quartz-augite-porphyrite from Nellore—Petrological notes on, 238.
Quavi, A. Error in the ages of Bengali boys, 323.
Quavi, A. Superstitions of Bengali teachers, 322.
Quincke's method of finding surface tension, 98.
Quinicine—Formation during sterilisation of quinine hydrochloride, 170.
Quinine hydrochloride—Formation of quinicine during sterilisation of, 170.

Rabbits, colour of—Their susceptibility to insulin, 274.
Radiation field, dualistic nature of, 84.
Radish plant—Carbohydrate-nitrogen balance in, 221.
Radish plant, life-cycle of 219, 220.
Radish plant—Photosynthetic activity of, 220.
Ragi (*Eleusine coracana*), 165.
Rai, H. *See* Āwati, P. R., and H. Rai.
Raju, V. G. Ferro-solvency of drinking waters, 271.
Raju, V. G. Mechanical gravity filters for purification of water, 271.
Ramakrishnan, T. S. *Thielaviopsis paradoxa*, 212.
Ramaswami, C. V., and R. V. Norris. Effect of sulphur oxidation on the microflora of activated sludge, 34.
Ramdas, L. A. Ellipticity of light reflected at the free surfaces of liquids at the Brewsterian angle, 101.
Ramdas, L. A. Origin of movements of camphor on water and other allied phenomena, 100.
Ramdas, L. A. Scattering of light by gaseous mixtures at high pressures, 101.
Rana afghana in the Western Himalayas, 205.
Rangasamy, K. *Vallisneria spiralis* L., 216.
Rangpur, origin of the place-name—Legends about, 303.
Rangpuri superstition, 302.
Ranjan, S. Sugar on respiration of leaves, 223.
Rao, A. N. Geometrical interpretation of the invariants of a pair of bilinear forms, 98.
Rao, C. V. H. Mutually self-polar triangles, 94.
Rao, D. A. R., and R. V. Norris. Estimation of iodine in soils, 167.
Rao, G. H. Statistical ethics, 328.
Rao, H. S. Gastropod molluscs from the Kangra valley, 197.
Rao, H. S. Jelly fishes of the Indian seas, 190.
Rao, L. R. Stigmatopygus vs. cyrtoma, 237.
Rao, M. B. *See* Ayyar, M. V., and M. B. Rao.
Rao. M. B., and M. V. Ayyar. Evaluation of special persymmetrics, 91.
Rao, M. G. S., and B. K. T. Iyengar. Nitro-acids of the β-resorcylic acid series, 151.
Rao, M. G. S., and C. Srikantia. Condensation products of derivatives of β-resorcylic aldehyde, 151.
Rao, M. G. S., and M. S. Iyengar. Substitution in resorcinol derivatives, 152.
Rao, P. K. *See* Ayyangar, G. N. R., and P. R. Rao.
Rao, S. L. Cassidulidæ from the upper cretaceous rocks, 237.
Rao, S. S. *See* Acton H. W., and S. S. Rao.
Rao, V. N. R. Yielding power of a strain of Mysore-American cotton compared with that of Cambodia and Dhawar-American, 32.
Rao, Y. R. *Amsacta albistriga*, 199.
Rau, K. V. *See* Pai, M. K., and K. V. Rau.
Ray, B. *See* Nishina, Y., and B. Ray.

Ray, C. B. Globulins in Kala-azar and syphilis, 279.
Ray, H. N. *Oligotoma* from Peradenyia, 198.
Ray, J. N. Synthetical experiments on the *iso*-quinoline alkaloids, 155.
Ray, J. N., and R. N. Ray. Synthesis of phenylated ureas and thio-ureas, 150.
Ray, N. N. *See* Ray, P. C., and N. N. Ray.
Ray, P. C., and K. C. Bose-Ray. Varying valency of gold. Inadequacy of Werner's theory, 132.
Ray, P. C., and K. C. Bose-Ray. Varying valency of platinum. Inadequacy of Werner's theory, etc., 132.
Ray, P. C., and N. N. Ray. Double sulphates of the copper magnesium group and the sulphonium bases, 131.
Ray, P. R. Smith-Stoner's classification of electron sub-groups and the co-valency conception as applied to simple and co-ordination compounds, 135.
Ray, P. R. *See* Das-Gupta, P. N., and P. R. Ray.
Ray, P. R., and A. K. Chattopadhya. Action of hexamethylene tetramine upon solutions of salts of the elements of group III, etc., 133.
Ray, P. R., and A. K. Chattopadhya. Action of rubeanic acid upon sodium cobaltinitrite, etc., 133.
Ray, P. R., and B. K. Goswami. Compounds of hydrazine with metallic sulphites and nitrites, 130.
Ray, P. R., and P. C. Banerjee. Constitution of infusible and fusible white precipitates of mercury, 130.
Ray, R. M. *See* Ray, J. N., and R. M. Ray.
Ray, S. Change of wave-length by transmission through a thickness of transparent glass, 99.
Ray, S. Possibly spurious character of "fine structure" of lines and of "continuous spectrum" of hydrogen, 99.
Ray-Chaudhuri, D. C. *See* Bose, P. K., and D. C. Ray-Chaudhuri.
Ray-Chaudhury, S. *See* Mukherjee, J. N., and S. Ray-Chaudhuri.
Ray-Chaudhuri, T. C. Some measurements of the Varendra Brahmins of Bengal, 307.
Reciprocal salt pairs and water—Systems formed by, 146, 147.
Refraction indices of some organic crystals and inorganic salts in aqueous solution, 136.
Refractive index of carbon dioxide gas—Action of magnetic field on, 102.
Resorcinol derivatives, substitution in, 152.
β-Resorcylic acid series—Nitro-acids of, 151.
β-Resorcylic aldehyde—Condensation products of derivatives of, 151.
Retention by visual and by kinæsthetic presentation, 326.
Reversal of bands, 74.
Rhizopods and flagellates from Kashmir, 189.
Rhyolites and rhyolite tuffs of Thaton dist., 239.
Riccia robusta Kashyap, 214.
Rice, blast disease of, 211.
Rice crop at Karjat, growth of, 222.
Ricinus fruits, respiration of, 218.
Rolling motion, problem of, 96.
Root development of paddy under different conditions of growth, 38.
Root habits of a xerophytic plant community, 223.
Root nodule organism of the leguminous plants, 210.
Roy, H. L. Experimental contribution to the theory of equation of state for adsorbed substances, 137.
Roy, H. N. Intestinal flagellates, 188.
Roy, H. N., and others. *Tetrachilomastix bengalensis* Chatterjee, 188.
Roy, M. N. *See* Sircar, A. C., and M. N. Roy.
Roy, S. C. Bull roarer in India, 300.
Roy, S. K. Hydro-electric power plant at Mandi, 241.
Rubeanic acid, action of—upon sodium cobaltinitrite, 133.
'Rust' of coffee—Varietal resistance to, 212.

Saha, M. Complete explanation of the spectra of the metals of the second group, 81.
Saha, M. Spectrum of neon, 82.
Sahni, B. *Ginkgo biloba*, 215.
Sahni, B. Indian fossil conifers, 215.
Saikia, T. C. Frog marriage in Assam, 306.
Salts of the elements of group III—Action of hexamethylene tetramine upon solutions of, 133.
Samanta, M. Influence of musical notes upon tremors, 325.
Sambamurti, G. Action of hydrogen sulphide on lead Peroxide, 134.
Sanocrysin treatment of tuberculosis, 265.
Sarcoids or acquired angeiomata, 277.
Sarin, N. N., and others. Effect of dyes on the lustre of silk fabrics, 164.
Sarkar, D. *See* Dutt, J. C., and Sarkar, D.
Sarkar, J. K. Forgetting and amnesia, 323.
Sarkar, S. L. Dream of an ascetic disciple, 319.
Sarma, R. N. Psychology of dreams in Upanishads, 320.
Sassurea lappa, 272.
Sastri, B. N. Simple method for concentrating enzyme solutions, 165.
Sastri, B. N., and R. V. Norris Studies on invertase, 165.
Satyapir legend in Santali guise, 304.
Sawhney, A. Capnodium on cotton, 211.
Sawhney, C. L. Frogs and toads from the Punjab, 204.
Scolopendra, eggs of, 201.
Scytonemataceæ, a new genus of, 209.
Sectarian marks of Hindus in South India, 300.
Seed testing, value of, 37.
Self-immolation for propitiating a god, 304.
Self-polar triangles, 94.
Semicarbazides, action of urea upon, 157.
Sen, A. K. *See* Ukil, A. A., and A. K. Sen.
Sen, B. M. Waves in basins, 86.
Sen, B. M. Waves in horizontal canals, 85.
Sen, H. D., and E. R. Watson. Extraction of papain from papaya, 168.
Sen, H. K. Presidential address: Section of Chemistry, 105.
Sen, H. K. *See* Bose, U., and H. K. Sen.
Sen, H. K., and C. Barat. Action of cyclohexeneoxide on ammonium chloride, 148.
Sen, H. K., and C. Barat. Cyclohexeneoxide and its hydrolysis by yeast, 167.
Sen, H. K., and K. L. Datta. Synthesis of O-alkyl ketones from hydroxymethylene ketones, 155.
Sen, H. K., and S. K. Ghosh. Interaction of diazonium salts with acetyl cycloketones, 150.
Sen, H. K., and S. Majumdar. Condensation of benzylidine ketones with cyanacetamide, 153.
Sen, J. Fossil wood from the Lalmai range in Commillah, 240.
Sen, K. C. Application of kinetic theory to surface films, 137.
Sen, M. Syntheses in the triazine series, 160.
Sen, N. R. Fresnel's convection co-efficient in general relativity, 84.
Sen, P. B. Formation and physical properties of urease, 165.
Sen, P. B. Microchemical method for locating urease within a cell, 166.
Sen, P. B. Urease content of seeds of Indian plants, 165.
Sen, P. C. *See* Guha, P. C., and P. C., Sen.
Sen, R. N., and G. Banerjee. "Neem" oil, 162.
Sen, R. N., and N. C. Chatterjee. Condensation of ketones, 153.
Sen, S. C. *See* Datta, S., and S. C. Sen.
Sen-Gupta, H. M. *See* Basu, N. M., and H. M. Sen-Gupta.
Sen-Gupta, I. Complex salts derived from *p*-nitrosodimethyl aniline and metallic chlorides, 134.
Sen-Gupta, N. N. Gestalt-theorie, 325.

Seraikela State—Iron slags from, 308.
Seraikela State—Stone implements from, 307.
Serological methods—Classification of lactose-fermenters by, 262.
Serpentines and the associated minerals of Henzada and Bassein districts, 239.
Seshadri, I. R. Double bond in coumarins and other carbonyl compounds, 153.
Seshadri, T. R., and P. Krishnamurti. Indol and acridine derivatives containing *a*-pyrone ring, 154.
Seshaiya, R. V. *Limnœa luteola* Lamarck, 196.
Sethi, M. L. *Pinus longifolia*, 215.
Sethi, R. L. Root development of paddy, etc., 38.
Setna, S. B. Observations on monocystids of the oligochætes and polychætes, 189.
Sewell, R. B. S. Study of zoology in India in the future, 177
Shah, N. M., and R. L. Alimchandani. Ignition points of sulphur and phosphorus, 130.
Shah, N. M., and R. L., Alimchandani. Titration of acids by a solution of sodium hydrogen phosphate, 134.
Shah, R. C. Chromoisomerism in amidines, 149.
Shah, R. C. Syntheses of diaryl *p*-aminobenzamidines, 149.
Sharif, M. Indian ticks of the family of Ixodidæ, 202.
Shoot-axis and the primary root, 216.
Shorea robusta forest of Bhowal, 224.
Shukla, P. P. Influence of sulphur atom on optical rotatory power, 160.
Silver nitrate solution—Action of alkaline ferricyanide on, 132.
Silver peroxide, constitution of, 132.
Silver salts, 144.
Simonsen, J. L. *See* Bhagvat, M. B., and J. L. Simonsen.
Simonsen, J. L. *See* Mirchandani, B. J., and J. L. Simonsen.
Simonsen, J. L. *See* Nair, S. U., and J. L. Simonsen.
Singh, B. Chemistry and physiology of tropical plants, 220.
Singh, B., and H. B. Dunnicliff. Determination of the equivalent weights of mercury, magnesium, tin and aluminium by the synthesis of their bromides, 132.
Singh, B., and others. Carbohydrate-nitrogen balance in radish plant, 221.
Singh, B. N., and K. Kumar. Photosynthetic activity of radish plant, 220.
Singh, B. N., and N. V. Apte. Growth of tropical plants, 219, 220.
Singh, B. N., and others. Carbohydrate-nitrogen balance in radish plant, 221.
Singh, B. N., and others. Chemistry and physiology of tropical plants, 220.
Singh, H. *See* Krishna, S., and H. Singh.
Singh, Narain, and others. Effect of impurities on the intensity and colour of phosphorescence of calcium sulphide, 137.
Singh, R. *See* Luthra, J. C., and R. Singh.
Singh, S. *See* Krishna, S., and S. Singh.
Singh, T. S. N., and others. Carbohydrate-nitrogen balance in radish plant, 221.
Singh, T. S. N., and others. Chemistry and physiology of tropical plants, 220.
Single tests as measures of general intelligence, 326.
Sinha, S. C. Psychology of advertisement, 324.
Sircar, A. C., and M. N. Roy. *a*-Pyridino-acenaphthenequinone, 155.
Sivan, M. R. R. Correction of lactometer readings for temperature, 171.
Sivan, M. R. R. Principles governing the application of manures, 168.
Sivan, M. R. R. Sedimentation method of mechanical analysis of soils, 167.
Smith-Stoner's classification of electron subgroups and co-valency conception as applied to simple and co-ordination compounds, 135.

Sodawater, manufacture of—from the chalk-derived water of a deep tube well, 273.
Sodium and potassium amalgams—Viscosity of, 141.
Sodium borate—Titration of acids by a solution of, 134.
Sodium cobaltinitrite—Action of rubeanic acid upon, 133.
Sodium hydrogen phosphate—Titration of acids by a solution of, 134.
Sodium nitrate from Chilean caliche—Cyclic processes in the manufacture of, 167.
Soil—Ammonia on the nitrifying power of, 33.
Soil—Fate of irrigation water and rainfall in, 35.
Soil fungi—Production of ammonia by, 34.
Soil nitrification changes—Well waters as a means of study of, 33.
Soils—Estimation of iodine in, 167.
Soils—Hypothesis of "unfree water" in, 37.
Soils, mechanical analysis of, 37.
Soils, nitrate content of, 33.
Soils—Sedimentation method of mechanical analysis of, 167.
Solanum melongena, apocarpy in, 216.
Solid phases, identification of, 147.
Somasundaram, P. M. *Achyranthes aspera* Linn., 216.
Somasundaram, P. M. Beliefs in the lunar periodicity in animals and plants, 306.
Somasundaram, P. M. Poo-nonbu in Kongu Nad, 306.
Somasundaram, P. M. Xerophytic plant community, 223.
Sondhi, G. Pigeon heavily infested with tape worms, 193.
Soni, C. L., and H. B. Dunnicliff. Determination of mixture of thiosulphates and sulphites, 133.
Sorghum vulgare, mucilage exudation of, 217.
South Indian acarina, 202.
Space limen in relation to the axis of rotation in the right arm, 328.
Spectra of the metals of the second group, 81.
Spectrum of argon, 78.
Spectrum of cobalt—Interpretation of, 80.
Spectrum of copper—Series relation in, 79.
Spectrum lines, fine structure of, 98.
Spectrum of neon, 82.
Spectrum of nickel, 78.
Speed and quality in Bengali handwriting, 322.
Spiders, eggs of, 200.
Sreenivasaya, M. Dilatometric investigations of enzyme action, 171.
Sreenivasaya, M. Enzymes of the lac insect with special reference to carboxylase, 172.
Srikantia, C. *See* Rao, M. G. S., and C Srikantia.
Srivastava, B. P., and K. Gopal. Nature of discharge through a neon tube, 99.
Stamp, L. D. Oil fields of Burma, 227.
Stannic hydroxide sol, adsorption and coagulation of, 144.
Statistical ethics, 328.
Stigmatopygus *vs.* cyrtoma, 237.
Stilbene and cinnamic acid, photobromination of, 146.
Stiles-Webb, H. G. Maternity and child welfare, 270.
Stone implements from the Seraikela State, 307.
Straw-chaff, feeding value of, 38.
String of suspension insulators—Voltage distribution on a, 104.
Strontium hydroxide octahydrate—Action of bromine solution in carbon tetrachloride on, 131
Subjective brightness in a circumscribed field, 325.
Subrahmanyam, S. G. Experimental harmonic motions coupled oscillations, 95.
Subrahmanyam, S. G. Projection of spectra, 95.
Sugar on respiration of leaves, 223.
Sugarcane, breeding improved—for the Punjab, 32.

Sulphinic acids—Volumetric estimation of -SOOH in, 164.
Sulphur dichloride, interaction of—with substances containing reactive methylene group, 172.
Sulphur monochloride, interaction of—with organic compounds containing reactive methylene group, 174.
Sulphur monochloride, interaction of—with substances containing the reactive methylene group, 173.
Sulphur oxidation, effect of—on the microflora of activated sludge, 34.
Sulphur oxidising organisms from activated sludge, 34.
Sulphur and phosphorus—Ignition points of, 130.
Sundararaman, S., and K. M. Thomas. 'Blast' disease of rice, 211.
Sunn hemp, manuring with, 33.
Super, home made—and its effect on potatoes, 34.
Superstitions of Bengali teachers, 322.
Sur, N. K. Interpretation of the spectrum of cobalt, 80.
Sur, N. K., and K. Majumdar. Thermal ionisation of elements, 76.
Surface—Fundamental magnitudes of the second order of a, being expressed separately in terms of those of the first order, 96.
Surface films, on the application of kinetic theory to, 137.
Surface reflectivity of liquids, 138.
Surface tension, Quincke's method of finding, 98.
Suri, P. N. Administration of calcium in chronic broncho-pneumonic-phthisis, 264.
Suryanarayana, M. *See* Viswa Nath, B., and M. Suryanarayana.
Swaminathan, V. S. Beryl from Nellore, 238.
Swaminathan, V. S. Granitic and gneissic rocks and quartz-augite-porphyrite from Nellore, 238.
Swaminathan, V. S. Kyanite from Nellore, 237.
Synemosyna Hentz., 202.
Syntengs—Matrimonial institutions of, 307.
Syphilis and Kala-azar—Globulins in, 279.
System $(NH_4)_2SO_4$—H_2SO_4—C_2H_5OH, 135.
Systems formed by water and reciprocal salt pairs, 146, 147.

Talesara, S. C. *See* Howard, A., and S. C. Talesara.
Tanquist, J. E. Calendar of the Angami Nagas, 302.
Tape worms—Pigeon infested with, 193.
Tartaric acid, photobromination of, 145.
Tendulkar, H. D. *See* Paranjpe, G. R., and H. D. Tendulkar.
Tension, interfacial—Studies in, 147.
Tetrachilomastix bengalensis Chatterjee, 188.
Thadani, K. I. Experiments on Egyptian cotton in Sind, 36.
Thakore, A. K., and R. V. Norris. Production of ammonia by soil fungi, 34.
Thapar, G. S. *Acanthogyrus*, 194.
Theory of equation of state for adsorbed substances—Experimental contribution to, 137.
Therapeutics in India, 243.
Thermal ionisation of elements, 76.
Thielaviopsis paradoxa, 212.
Thiobiazole and oxybiazole—Syntheses in, 158.
Thiodiazines, 156, 157.
o-Thiol-phenyl-hydrazine—Attempt towards the synthesis of, 159.
Thiosemicarbazides, action of urea upon, 157.
Thiosemicarbazone series, studies in, 157.
Thiosulphates and sulphites—Determination of mixture of, 133.
Thioureas, synthesis of, 150.
Thomas, K. M. 'Rust' of coffee, 212.
Thomas, K. M. *See* Sundararaman, S., and K. M. Thomas.
Thomas, T. H. Love of music, 319.
Thomas, W. M. (Jr.). Mysticism and psychology, 327.

Titration of acids by a solution of sodium borate, 134.
Titration of acids by a solution of sodium hydrogen phosphate, 134.
Tiwary, N. K. Behaviour of the radicle and plumule of Eugenia, 219.
Tiwary, N. K. Nyctitropic movements of cotyledons of *Cassia tora*, 219.
Toluene and benzaldehyde—Photochemical oxidation of, 147.
Tomb, J. W., and G. C. Maitra. Absence of specific agglutinius blood of healthy carriers of Koch's vibrio, 268.
Tomb, J. W., and G. C. Maitra. Origin of cholera epidemics, 268.
Tortoise in Indian life and religion, 301.
Toshniwal, G. R. Arc spectrum of bismuth, 81.
Totemism in South India, 301.
Toxicity of mature and immature genuine spirits, 273.
Trapa-bispinosa—Food value of the nut of, 272.
Trematode parasites of a Burmese house-crow, 191.
Trematodes and cestodes, 193.
Trematodes from reptiles, 191.
Tremors—Influence of musical notes upon, 325.
Triazine series, syntheses in, 160.
Tricalcium sucrate, formation of, 169.
Trigonometric expansion—Coefficients in, 90.
Tropical plants—Chemistry and physiology of, 220.
Tropical plants, growth of, 219, 220.
Tropical sunlight, action of—on bacteria, 269.
Tuberculin test—Observations on, 275.
Tuberculosis, application of our knowledge of—to Indian conditions, 264.
Tuberculosis—Complement fixation test in the diagnosis of, 265.
Tuberculosis—Sanocrysin treatment of, 265.
Tuberculosis among cattle of the Madras Corporation, 276.
Tuberculosis in India—Incidence and types of, 266.
Tuberculosis by massive infection—Mortality due to, 282.
Tumours caused by intraperitoneal inoculation of *B. lepra murium*, 264.
Turpenes, open chain—Attempts to prepare, 169.

Ukil, A. A., and A. K. Sen. Gram-negative non-lactose-fermenting bacilli in the causation of bacillary dysentery in Bengal, 269.
Ukil, A. C. Anærobic infections in India, 267.
Ukil A. C. Simplified cold incubator, 281.
Ukil, A. C. Types of tuberculosis met with in India, 266.
Ukil, A. C., and M. M. Basu. Action of antiseptics on bacteria, 270.
Ukil, A. C., and M. M. Basu. Action of tropical sunlight on bacteria, 269.
"Unfree water," hypothesis of— in soils, 37.
Unity of life, 5.
Untouchables among animals and plants, 301.
Uranyl salts—Absorption of light in presence of, 145.
Urease—Formation and physical properties of, 165.
Urease—Microchemical method of locating within a cell, 166.
Urease content of seeds of Indian plants, 165.

Vaccinia virus from the virus of contagious epithelioma of fowls, 262.
Valency of gold, 132.
Valency of platinum, 132.
Vallisneria spiralis L., embryology of, 216.
Varendra Brahmins of Bengal—Some measurements of the, 307.
Variation of pitch with amplitude, 98.
Varma, P. S., and B. Narayan. Bromination of benzene, 148.
Varma, P. S., and C. K. Menon. Nitration of naphthalene, 148.
Varma, P. S., and K. G. R. Panicker. Influence of substituents in the benzene nucleus on nitration, 149.
Varma, P. S., and K. G. R. Panicker. Iodination of aromatic hydrocarbons, 148.

Varma, P. S., and P. V. Krishnamurthy. Simultaneous diazotisation and nitration of aromatic amino-compounds, 149.
Vasisht, B. R., *Ophioglossum aitchisoni* D'Almeida ; and *O. vulgatum* L., 215.
Venkataraman, A. A., and B. B. Dey. Kinetics of the decomposition of mercuric formate, 147.
Venkataraman, K. Mucilage exudation of *Sorghum vulgare*, 217.
Venkataraman, T. S. Breeding improved sugarcanes for the Punjab, 32.
Verma, S. C. Trematodes and cestodes, 193.
Vicia faba—Influence of light and darkness upon, 221.
Viscosity of sodium and potassium amalgams, 141.
Viscosity of sols in presence of electrolytes, 142.
Viscosity and surface tension, 136.
Vision, indirect—Perception of forms in, 324.
Visual brightness—Demonstration of Weber's law in the field of, 325.
Visual presentation—Retention by, 326.
Vocabulary study of two children, 324.
Volcanoes of Burma, 240.
Voltage distribution on a string of suspension insulators, 104.
Vyas, N. D. Home made super and its effect on potatoes, 34.

Warth, F. J. Capacities of Indian cattle for food consumption and digestion, 27.
Water, catalytic oxidation of, 135.
Watson, E. R. *See* Mulany, H. M., and E. R. Watson.
Watson, E. R. *See* Sen, H. D., and E. R. Watson.
Watson, E. R., and others. Formation of pure tricalcium sucrate, 169.
Watson, H. E. *See* Ghosh, D. N., and H. E. Watson.
Watson, H. E. *See* Kothari, C. J., and H. E. Watson.
Watson, H. E., and others. Preparation of ethers by the use of solid catalysts, 147.
Wave-length, change of—by transmission through a thickness of transparent glass, 99.
Waves in basins, 86.
Waves in horizontal canals, 85.
Weber's law, demonstration of—in the field of visual brightness, 325.
Well waters, seasonal composition of—as a means of study of soil nitrification changes, 33.
Werner's theory, inadequacy of, 132.
West, M. Psychology and the school text-book, 323.
Wheat plants, growth of— and correlations between certain wheat characters, 36.
Wilsdon, B. H. Fate of irrigation water and rainfall in the soil, 35.
Wilsdon, B. H. Hydrodynamical problems connected with turbulent flow in earthern channels, 87.
Wilsdon, B. H. Mole drainage, 35.

X-radiation, scattered,—Barkla effect with, 101.
X-ray lines, relative intensity of, 83.
Xerophytic plant community—Root habits of, 223.

Yajnik, N. A., and others. Chromatic emulsions, 140.
Yajnik, N. A., and others. Effect of dyes on the lustre of silk fabrics, 164.
Yajnik, N. A., and others. Effect of impurities on the intensity and colour of phosphorescence of calcium sulphide, 137.
Yajnik, N. A., and others. Effect of time on the gelating sols, 140.
Yajnik, N. A., and others—Factors governing the hygroscopicity of aqueous crystal, 138.
Yajnik, N. A., and others. Studies in photo-sols, 141.
Yajnik, N. A., and others—Surface reflectivity of liquids, 138.

Yoganandam, E. *See* Choudary, K. S., and E. Yoganandam.
Yoganandam, E., and others. Adulteration in Madras bark-tanned skins and hides, 170.
Yoganandan, G. Predetermination of the voltage distribution on a string of suspension insulators, 104.

Zadoo, V. D., and others. Studies in photo-sols, 141.
Zoology in India in the future—Study of, 177.

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Sadanand, Professor, Multan College, Multan.
Sahni, Gyan Prakash, c/o L. Lajpat Rai, Sleem Buildings, Lahore.
Sahni, Mrs. B., Rattigan Road, Lahore.
Sahni, Satya Prakash, c/o L. Lajpat Rai, Sleem Buildings, Labore.
Sahni, Miss Raj Mohini, c/o L. Lajpat Rai, Sleem Buildings, Lahore.
Sarathy, R. P., c/o. R. S. Raghavan, Govt. House, Lahore.
Sawhney, A., M.Sc., Botany Department, Punjab University, Lahore.
Sen-Gupta, Jogendra Kumar, 3, Sitaram Ghosh Street, Calcutta.
Seth, Ram Chandra Telwar, c/o. Professor N. A. Yajnik, F. C. College, Lahore.
Shroff, H. B., B. Sc., Tech., A.I.C., Principal, Govt. School of Dyeing & Printing, Cawnpore.
Shukla, P. P., Indian Institute of Science, Bangalore.
Singh, Balwant, M. Sc., University Chemical Laboratories, Lahore.
Singh, Jogindra, M. B. B. S., c/o Messrs. Sadhbans & Co., Auditors, 21, Nisbet Road, Lahore.
Singh, Mahabir, M. Sc., 21, Belvedere Road, Calcutta.

Singh, Sardul, Assistant Engineer, Mahan Singh Gate, Amritsar.
Singh, Sundar, M. Sc., G. N Khalsa College, Gujranwala.
Shastri, B. N., Indian Institute of Science, Bangalore.
Singh, Bhola Nath, Benares Hindu University, Benares.
Singh, Daushan, 16, Lawrence Road, Lahore.
Singh, Mahtab, Irrigation Research Laboratory, P. W. D., Lahore.
Singh, Sachdev, Government Intermediate College, Multan.
Sovani, S. V., 255, Girgaon Road, Bombay—4.
Sreenivasan, K., Department of Elec. Technology, Indian Institute of Science, Bangalore.
Suri, Girdhar Lal, M. Sc., Research Asst. to Dyeing Expert, Govt. Institute of Dyeing, and Calico Printing, Shahdara, Lahore.
Suri, Durga Dass, B.Sc., Punjab Agricultural College, Lyallpur.
Suri, Dr. H.C., The Palms, Old Anarkali, Lahore.
Suri, Mrs. H.C., The Palms, Old Anarkali, Lahore
Suri, M.C, Forman Christian College, Lahore.
Suri, Mrs. Premnath, 25 Nisbet Road, Lahore.
Swami, Narayan, Punjab Vety. College, Lahore.

T

Thakur, A. K., Indian Institute of Science, Bangalore.
Thapar, Miss P., 30, Nisbet Road, Lahore.
Tej Ram, Rai Bahadur, Executive Engineer, 7, Rattigan Road, Lahore.
Thomas, Wendell M. (Jr.), Forman Christian College, Lahore.

V

Vasudeva, Dina Nath, M.Sc., Demonstrator in Physics, Govt. College, Lahore.

Y

Yoganandan, G., High Tension Laboratory Asst., Dept. of Electrical Technology, Indian Institute of Science, Bangalore.

Z

Zadoo, Vasu Dev, M.Sc., S.P. College, Srinagar.
Zutshi, Bishambar Nath, B.Sc., Kashmir Bhawan, Lachhmi Narain Street, Anarkali, Lahore.

STUDENT MEMBERS.

A

Aggarwal, Nathu Ram, B. Sc.
Aggarwala, Miss.
Ahmad Ali.
Akhtar, Abdul Rashid.
Ali Bashir.
Amar Chand.
Amba Prasad.
Amolak Ram.
Anand, Mulk Raj.
Arjun Dass.
Arora, Guran Lal.
Autar Singh.

B

Badhwar, Rattan Lal.
Balbir Singh.
Baldev Singh.
Balwant Singh.
Banwari Lal.
Bhagat, N. C.
Bhalla, Hans Raj.
Bhandari, Dharam Pal.
Bhardwaj, Nand Kishore.
Bhatia, Madan Lal.
Bhatia, Rattan Lal. M.Sc.
Bhatnagar, Mool Chand.
Bhishamji.
Bonnerjee, S. K., B.T.
Budhiraja, Kashmiri Lal.

C

Chadha, Sukh Dial.
Chaman Lal.
Chaman Lal.
Chand Narain
Chandar Bhan.
Chawla, Madan Gopal.
Chona, Bihari Lal.
Chopra, Kundan Lal.
Chopra, Ram Saran.
Chopra, Ranbir Lal.

D

Darbar Singh.
Darbari, Nand Lal.
Daulat Ram.
Dayal Singh.
Des Raj.
Dev Dutt.
Dev Raj.
Dhanwanti Mahez.
Dharam Singh.
Dina Nath.
Diwan Chand.
Dixit, Suresh C.
Dutt, Jogendra, B.T.

F

Fonseca, Miss Mary.

G

Ganguli, N. K.
Girdhari Lal.
Gobind Ram.
Gopal Krishna.
Gopal Singh.
Gulati, Harbans Lal.
Gupta, Amar Nath, B.Sc.
Gupta, Har Charan Dass.
Gurbux Singh.

H

Hans Raj.
Hans Raj.

I

Imtiaz-ul-Haq, M.
Ishwar Dass.
Ismail, P. M.

J

Jain, Bimal Dass.
Jain, Gian Chand.
Jain, Narendra Prasad.
Jamiat Rai.
Joshi, Amar Chand.
Joshi, M. L.

K

Kalia, Har Gobind.
Kapur, Amar Nath.
Kapur, Chuni Lal.
Kapur, Ram Narain.
Kayastha, Hem Raj.
Khajuria, Ram Lal.
Khanna, Vidya Nath.
Khosla, M.M.
Kohli, Mulkh Raj.
Krishna, S.
Kunj Lall, B.Sc.

L

Lahiri, T. K.
Lakshmi Narain.
Lal Chand.
Luke, H. B.

M

Madan Lal.
Madho Lal.
Mahajan, Prakash Chandar.
Makhan Lal.
Malhotra, Kishori Lal, M.Sc.
Maya Devi (Miss).
Mehta, Dev Raj.
Mohan Lal.
Mohan Prakash.
Mohd. Ali.
Mohd. Azam.
Mohd. Ishaq.
Mohindra Singh.
Moudgill, M.M.
Mukerjee, H. C., B.T.

N

Narayanaswami, P. M.
Narendra Nath.
Nayar, Sham Lal.
Nazir Ahmad.

O

Om Prakash.

P

Parimoo, Jai Lal.
Patro, Y. A.
Prashar, Sardari Lal.
Puri, Baij Nath.
Puri, B. S.
Puri, Nand Lal.
Pyare Lal.
Pyare Lal.

Q

Quadvi, Ainut, B.A., B.T.

R

Raina, Jai Lal.

Ram Dass.
Rama Krishna.
Ram Lal.
Ram Saran Dass.
Ram Sarup.
Ram Singh.
Ray, M. B.
Rewati Raman.
Rishi, Madan Gopal.

S

Sahai, Prem Nath.
Sahai, Raghunath.
Sahni, Roop Chand.
Sanan, Barkat Ram.
Sardar Mohd.
Sardar Singh.
Sarkar, Devendranath, B.T.
Satya Pal.
Sawhney, C. L.
Sen, J. M.
Seth, Purshotam Dass.
Sethi, R. R.
Sham Lall.
Shamboo Nath
Shamboo Ram.
Shanti Narain.
Shanti Sarup.
Shanti Suvan.
Sharma, Joti Prasad.
Shiv Nath.
Shri Nivas.
Singh, Jagdhir.
Singh, Jagjivan.
Singh, Jugat, M.Sc
Sita Ram.
Sud, Amar Nath.
Surjan Singh, B.A.
Sarin, N. N.

T

Taneja, Hari Chand.
Tara Chand.
Tuli, Ram Lal.

V

Varma, Jai Dev.
Vasudeva, Dev Dutt.
Vasudeva, Hari Dutt.
Vesakhi Ram.
Virmani, Baldev Dutt.
Vyas, Hari Chand.

Y

Yudhista Alagh.

Z

Zutshi, Miss.
Zutshi, Radha Krishna.

RULES.

INDIAN SCIENCE CONGRESS.

I. The administrative work of the Congress shall be carried on by an Executive Committee, who shall submit such questions as they think desirable to a General Committee at its annual meeting or at a special meeting of which satisfactory notice shall be given.

II. The General Committee shall consist of all full members (*Vide Rule XI ;*) who have attended three meetings (including that actually taking place at any time) and those members who have held office in the Congress. This Committee shall meet at least once at each Congress, usually in the middle of the meeting.

III. The Executive Committee shall consist of the President, the retiring President, the two General Secretaries, the Treasurer of the Asiatic Society of Bengal, the General Secretary of the Asiatic Society of Bengal and three members elected by the General Committee at its Annual General Meeting. The Executive Committee shall have full powers to transact all business in case of need, notwithstanding any limitations herein laid down.

IV. The Council shall consist of the members of Executive Committee, of the Past Presidents resident in India and five other members appointed by the General Committee at its annual meeting.

The Council shall be consulted on matters of general scientific importance and policy.

V. The nomination of the President shall be made by the Executive Committee and submitted for confirmation to the General Committee.

VI. The Sectional Presidents shall be appointed by the Executive Committee.

(*Experience shows that there is not time for any other arrangement to work satisfactorily.*)

VII. The two General Secretaries shall be nominated by the Executive Committee and submitted to the General Committee for confirmation.

VIII. As long as the present relationship with the Asiatic Society of Bengal continues, the General Secretary and the Treasurer of that Society shall be members of the Executive Committee.

IX. The Local Secretary (or Secretaries) and the Local Committee for any meeting of the Congress shall be appointed by the Executive Committee.

X. The Local Secretary (or Secretaries) and the local Committee shall assist in making arrangements for the reception and entertainment of the visitors and for the distribution of letters at the meeting.

XI. There shall be three classes of members :—

(i) *Full members :* Annual subscription *Rupees ten.*
(ii) *Associate members :* Annual subscription *Rupees five.*
(iii) *Student members :* Annual subscription *Rupees two.*

(Student members must be definitely certified by the principal of their College as *bona fide* students.)

Only full members have the right of communicating papers to the Congress and they receive free of charge all publications. Associate and Student members have the right of reading papers before the Congress provided they have been communicated by a Full Member.

[1] XII. The following procedure is to be adopted for making any additions or alterations in the above rules:—

(*a*) Proposals for additions to and alterations in the existing rules are to be sent to the General Secretary at least two months before the meeting of the General Committee at which they are to be moved. The General Secretary, on receipt of such proposals, shall circulate them to all members of the General Committee who paid their annual subscription at the last session of the Congress.

(*b*) Any amendments to the proposals shall be sent to the General Secretary at least a fortnight before the meeting of the General Committee.

[1] XIII. The proposals with amendments shall be brought up before the meeting of the General Committee (with remarks of the Executive Committee, if any) and declared carried, if accepted by a two-thirds majority of those present at the meeting.

Sectional Committees.

XIV. (*a*) The Sectional Committees shall consist of not more than three members who shall be

(1) The President of the Section (convenor).
(2) The retiring President of the Section.
(3) One member elected by the General Committee at its Annual General Meeting.

(*b*) The Sectional Committee shall arrange and referee all papers to be read before the Section.

(*c*) The Sectional Committee shall have power to fill vacancies during the year of their appointment.

(*d*) The Sectional Committee shall nominate annually a President for the section for the consideration of the Executive Committee.

Papers.

[2] XV. (*a*) An abstract of any paper to be read at the Indian Science Congress must be submitted to the General Secretary or the President of the Section concerned not later than the 15th of October. [This will enable the abstracts to be printed and circulated to members before leaving their Stations to attend the Congress.]

(*b*) All papers which are to be read must be referreed by the Sectional Committee or by some person appointed by them, the decision to be final and all reports confidential. In deciding whether a paper should be read the Sectional Committees will take into consideration the question whether the paper has been previously published.

(*c*) Each paper must be accompanied by an abstract and if the paper be of great length, it should be summarised.

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[1] Added at the Bangalore Meeting, 1924.
[2] Emended at the Benares Meeting, 1925.

OFFICERS OF THE FIRST THIRTEEN MEETINGS OF THE INDIAN SCIENCE CONGRESS.[1]

(1914-1926.)

PATRONS.

1914. H.E. The Rt. Hon. Thomas David Baron Carmichael of Skirling, G.C.I.E., K.C.M.G., Governor of Bengal.
1915. H.E. The Rt. Hon. Baron Pentland of Lyth, G.C.I.E., Governor of Madras.
1916. His Honour Sir James Scorgie Meston, K.C.S.I., Lieutenant-Governor of the United Provinces.
1917. H.H The Maharajah of Mysore, G.C.S.I.
1918. H.E. Sir Michael O'Dwyer, G.C.I.E., K.C.S.I., Lieutenant-Governor of the Punjab.
1919. H.E. Sir George Lloyd, G.C.I.E., D.S.O., Governor of Bombay.
1920. The Hon'ble Sir Benjamin Robertson, K.C.S.I., K.C.M.G., C.I.E., LL.D., I.C.S., Chief Commissioner, Central Provinces.
1921. H.E. The Rt. Hon. The Earl of Ronaldshay, G.C I.E., Governor of Bengal.
1922. H.E. Lord Willingdon, G.C.S.I., G.C.I.E., G.B.E., Governor of Madras.
1923. H.E. Sir William Marris, K.C.S.I., K.C.I.E., Governor of the United Provinces.
1924. H.H. The Maharajah of Mysore, G.C.S.I., G.B.E.
1925. H.H. The Maharajah of Benares, G.C.S.I., G.C.I.E.
1926. H.E. The Rt. Hon. Sir Leslie Wilson, P.C., G.C.I.E., C.M.G. D.S.O., Governor of Bombay.

CONGRESS PRESIDENTS.

1914. The Hon. Justice Sir Asutosh Mukherjee, Kt., C.S.I., M.A., D.L., F.A.S.B.
1915. Major-General W. B. Bannermann, C.S.I., M.D., D.Sc., I.M.S.
1916. Colonel Sir Sydney Burrard, K.C.S.I., F.A.S.B., F.R.S., R.E.
1917. Sir Alfred Gibbs Bourne, K.C.I.E., D.Sc., F.R.S.
1918. Dr. Gilbert T. Walker, C.S.I., M.A., Sc.D., F.R.S.
1919. Lt.-Colonel Sir Leonard Rogers, Kt.. C.I.E., M.D., B.S., F.R.C.P., F.R.C.S., F.A.S.B., F.R.S., I.M.S.
1920. Sir Prafulla Chandra Ray, Kt., C.I.E., Ph.D., D.Sc., F.A.S.B.
1921. Sir Rajendra Nath Mookerjee, K.C.I.E., K.C.V.O.
1922. C. S. Middlemiss, Esq., C.I.E., B.A., F.A.S.B., F.R.S.
1923. Sir M. Vishweshwarayya, K.C.I.E., M. Inst. C.E., D.Sc.
1924. Dr. N. Annandale, C.I.E., D.Sc., F.A.S.B., F.R.S.
1925. Dr. M. O. Forster, F.R.S.
1926. A. Howard, Esq., C.I.E., M.A.

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[1] As no full record of the Officers of the Congress appears in the Proceedings of its first twelve meetings, an attempt has been made to draw up a complete list regarding all the previous meetings. This list is here added as an appendix. A careful scrutiny has been made of the available registers, reports and other documents, but discrepancies and, in a few cases, gaps have been found. The list here presented is as correct and complete as the available material allows.

COUNCIL.*

1923.

Sir Asutosh Mukherjee.
Sir Gilbert T. Walker.
Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Vishweshwarayya.
C. S. Middlemiss, Esq.
Dr. J. L. Simonsen.
Prof. C. V. Raman.
Johan van Manen, Esq.
Dr. S. P Agharkar.
Prof. Sampathiengar.
Dr. K. N. Bahl.
Dr. Kunjan Pillay.
Dr. Nilratan Dhar.

1924.

Sir Asutosh Mukherjee (†7th May, 1924).
Sir Gilbert T. Walker.
Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Vishweshwarayya.
Dr. Annandale (†10th April, 1924).
Dr. J. L. Simonsen.
Prof. C. V. Raman.
Dr. S. P. Agharkar.
Dr. Baini Prashad.
Johan van Manen, Esq.
Prof. Sampathiengar.
Dr. K. N. Bahl.
Dr. Kunjan Pillay.
Dr. Nilratan Dhar.
Dr. J. N. Mukherjee.

1925.

Sir P. C. Ray, Kt.
Sir R. N. Mookerjee.
Sir M. Vishweshwarayya.
Dr. M. O. Forster.
Dr. Baini Prashad.
Dr. J. L. Simonsen.
Dr. S. P. Agharkar.
Dr. S. L. Hora.
Dr. E. R. Watson.
Dr. D. M. Bose.
Johan van Manen, Esq.
Prof. H. C. Das-Gupta.
Prof. G. Mathai.
Prof. S. L. Ajrekar.
Mr. A. Howard.
Dr. B. Sahni.

1926.

A. Howard, Esq.
Dr. M. O. Forster.

---

* The Council was established by a resolution of the General Committee in 1922 at Madras and was first constituted in 1923.

Prof. B. Sahni.
Dr. S. L. Hora.
Johan van Manen, Esq.
Dr. Prof. Roland V. Norris.
Prof. S. P. Agharkar.
Sir P. C. Ray, Kt.
Sir R. N. Mukherjī.
Sir M. Vishweshwarayya.
Prof. S. L. Ajrekar.
Prof. D. M. Bose.
Prof. H. C. Das-Gupta.
Dr. E. R. Watson.
Sir J. C. Prose.
Prof. C. V. Raman.
Major R. B. Seymour-Sewell.
Prof. G. Mathai.

EXECUTIVE COMMITTEE.

1916.

Sir Alfred Bourne.
Sir Sydney Burrard.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. F. H. Gravely (Gen. Sec., A.S.B.).

1917.

Dr. Gilbert T. Walker.
Sir Alfred Bourne.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon. (In England.).
R. D Mehta, Esq. (Treasurer, A.S.B.).
Dr. F. H. Gravely (Gen. Sec., A.S.B.).

1918.

Sir Leonard Rogers.
Dr. Gilbert T. Walker.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon. (In England.).
R. D. Mehta, Esq. (Treasurer, A.S B.).
Dr. F. H. Gravely (Gen. Sec. A.S.B., up to end of February).
Dr. W. A. K. Christie (Gen. Sec., A.S.B., from March).

1919.

Sir P. C. Ray, Kt.
Sir Leonard Rogers.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.
R. D. Mehta, Esq. (Treasurer, A.S.B.).
Dr. W. A. K. Christie (Gen. Sec., A.S.B.).

1920.

Sir R. N. Mookerjee.
Sir P. C. Ray, Kt.
Dr. J. L. Simonsen.
Prof. P. S. MacMahon.

Oswald Martin Esq. (Treasurer, A.S.B.).
Dr. W. A. K. Christie (Gen. Sec., A.S B , up to May).
A. H. Harley, Esq. (Gen. Sec , A.S B., from May).

1921.

Sir Thomas Holland (up to ?).
C. S. Middlemiss, Esq. (from ?).
Sir R. N. Mookerjee.
Dr. J. L Simonsen.
Prof. P. S. MacMahon.
Oswald Martin, Esq. (Treasurer, A.S.B., up to November).
A H. Harley, Esq. (Treasurer, A S B., from November).
Dr. W. A. K. Christie (Gen. Sec., A.S.B.).

1922.

Lt.-Col. A. T. Gage (up to ?).
Sir M. Visweshwarayya (from ?).
C. S. Middlemiss, Esq.
Dr. J. L. Simonsen.
Dr. C. V. Raman.
W. R. C. Brierley, Esq. (Treasurer, A.S.B.).
Dr. W. A. K. Christie (Gen. Sec., A.S.B., up to March).
Dr. S. W. Kemp (,, ,, up to July).
Dr. E. P. Harrison (,, ,, up to 31st August).
A. H. Harley, Esq. (,, ,, up to end of September).
Dr. S. W. Kemp (,, ,, from October).

1923.

Sir Asutosh Mukherjee. (Resigned in November.)
Dr. N. Annandale (from November).
Sir M. Visweshwarayya.
Dr. J. L. Simonsen
Dr. C. V. Raman (Gen. Sec., I.Sc.C., and Treasurer, A.S.B.).
Dr. S W. Kemp (Gen. Sec., A.S.B., up to February).
Johan van Manen, Esq., (Gen. Sec., A.S.B., from February).

1924.

Dr. M. O. Forster.
Dr. N. Annandale (†10th April).
Dr. J. L. Simonsen. (In England from April).
Dr. C. V. Raman (up to May).
Dr. S. P. Agharkar (from May).
Dr. N. R. Dhar.
Dr. Baini Prashad (Treasurer, A.S.B.).
Johan van Manen, Esq. (Gen. Sec., A.S.B.).

1925.

A. Howard, Esq.
Dr. M. O. Forster.
Dr. J. L. Simonsen.
Dr. S. P. Agharkar.
Dr. B. Sahni.
Dr. Baini Prashad (Treasurer, A.S.B., up to 3rd August).
Dr. S. L. Hora (,, ,, from 3rd August).
Johan van Manen, Esq. (Gen. Sec., A.S.B.).

1926.

A. Howard, Esq.
Sir J. C. Bose Kt.
Prof. C. V. Raman.
Prof. B. Sahni.
Major R. B. Seymour-Sewell.
Dr. S. L. Hora (Treasurer, A.S.B.).
Johan van Manen, Esq. (Gen. Sec , A.S.B.).
Prof. S. P. Agharkar.
Prof. Roland V. Norris.

(*N.B.*—The General Secretary and Treasurer of the Asiatic Society of Bengal are *ex-officio* members of the Executive Committee of the Congress.)

GENERAL SECRETARIES.

1914. D. Hooper, Esq.
1915. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1916. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1917. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1918. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1919. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1920. Prof. J. L. Simonsen.
Prof. P. S. MacMahon.
1921. Prof. J. L. Simonsen.
Prof. P. S. MacMahon (up to April).
Dr. C. V. Raman (from April).
1922. Prof. J. L. Simonsen.
Prof. C. V. Raman.
1923. Prof. J. L. Simonsen.
Prof. C. V. Raman.
1924. Prof. J. L. Simonsen.
Prof. C. V. Raman (up to May).
Prof. S. P. Agharkar (from May).
1925. Prof. J. L. Simonsen.
Prof. S. P. Agharkar.
1926. Prof S. P. Agharkar.
Prof. Roland V. Norris.

TREASURERS.

1914. D. Hooper, Esq.
1915. R. D. Mehta, Esq.
1916. R. D. Mehta, Esq.
1917. R. D. Mehta, Esq.
1918. R. D. Mehta, Esq.
1919. R. D. Mehta, Esq.
1920. Oswald Martin, Esq.
1921. Oswald Martin, Esq. (up to 24th November).
A. H. Harley, Esq. (from 24th November).
1922. W. E. C. Brierley, Esq.
1923. Dr. C. V. Raman.
1924. Dr. C. V. Raman (up to May).
Dr. Baini Prashad (from May).
1925. Dr. Baini Prashad (up to 3rd August).
Dr. S. L. Hora (from 3rd August).
1926. Dr. S. L. Hora.

(*N.B.*—The Treasurer of the Asiatic Society of Bengal was *ex-officio* Treasurer of the Congress.)

SECTIONAL PRESIDENTS.

Agriculture.

1915. Dr. H. H. Mann, D.Sc.
1916. B. Coventry, Esq., C.I.E.
1917. J. MacKenna, Esq., C.I.E., M.A.
1918. Dr. L. C. Coleman, D.Sc.
1919. G. F. Keatinge, Esq., C.I.E.
1920. D. Clouston, Esq., C.I.E., M.A., B.Sc.
1921. S. Milligan, Esq., M.A., B.Sc.
1922. Rao Sahib M. R. Ramaswami Sivan, B.A., L.Ag.
1923. Dr. N. Kunjan Pillay, M A., B.Sc., Ph.D.
1924. B. C. Burt, Esq., M.B.E., B.Sc.
1925. R. S. Finlow, Esq., B.Sc , F.I.C.
1926. G. S. Henderson, Esq., N.D.A., N.D.D.

Physics and Mathematics.[1]

1914. V. H. Jackson, Esq., M.A.
1915. Dr. C. V. Raman, M.A.
1916. Dr. G. C. Simpson, C.B.E., F.A.S.B., F.R.S.
1917. The Rev. Dr. D. Mackichan, D.D., LL.D.
1918. Dr. Wali Mohammad, M.A.
1919. Dr. D. N. Mallik, B.A., F.R.S.E.
1920. Dr. N. A. F. Moos, F.R.S.E.
1921. J. H. Field, Esq., M.A.
1922. T. P. Bhaskara Shastri, Esq., M.A., F.R.A.S.
1923. Dr. S. K. Banerjee, D Sc.
1924. Prof. C. V. Raman, M.A., D.Sc., F.R.S.
1925. Prof. E. P. Metcalfe, B.Sc., F.Inst. P.
1926. Prof. Megh Nad Saha, D.Sc., F. Inst. P.

Chemistry.

1914. P. S. MacMahon, Esq., M.Sc., B.Sc.
1915. Sir P. C. Ray, Kt., C.I.E , Ph.D., F.A.S.B.
1916. Dr. J. J. Sudborough, F.I.C.
1917. Dr. J. L. Simonsen, F.I.C., F.A.S.B.
1918. Dr. G. J. Fowler, F.I.C.
1919. F. L. Usher, Esq., B.Sc.
1920. B. K. Singh, Esq., M.A., F.I.C.
1921. Dr. H. E. Watson, A.I.C.
1922. Dr. N. R. Dhar, F.I.C.
1923. Dr. A. N. Meldrum, D.Sc.
1924. Dr. E. R. Watson, M.A., D.Sc.
1925. Prof. J. C. Ghosh, D.Sc.
1926. Dr. B. B. Dey, D.Sc.

Zoology.

1914. Dr. J. R. Henderson, C.I.E.
1915. Dr. N. Annandale, F.A.S.B.

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[1] A note states that, in 1917, there was a separate section of Mathematics, with Dr. Zia-ud-din Ahmed, C.I.E., as President. The Proceedings for that year contain no reference to this.

1916. Dr. W. N. F. Woodland.
1917. K. Ramunni Menon, Esq., M.A.
1918. Dr. B. L. Chaudhuri, B.A., F.R.S.E.
1919. F. M. Howlett, Esq., B.A., F.E.S.
1920. E. Vredenburg, Esq., A.R.S.M., A.P.C.S., F.A.S.B.
1921. Dr. F. H. Gravely, F.A.S.B.
1922. Dr. N. Annandale, F.A.S.B., C.M.Z.S.
1923. Prof. G. Mathai, M.A. (Cantab), F.Z.S.
1924. Dr. K. N. Bahl, D.Sc., Ph.D.
1925. Dr. Baini Prashad, D.Sc.
1926. Dr. H. R. Mehra, M.Sc., Ph.D.

Botany.

1914. C. C. Calder, Esq., B.A.
1915. Dr. C. A. Barber, C.I.E.
1916. A. Howard, Esq., C.I.E., M.A.
1917. Rao Bahadur K. Ranga Achari, M.A.
1918. R. S. Hole, Esq., C.I.E., F.C.H., F.L.S., F.E.S.
1919. S. R. Kashyap, Esq., M.Sc., B.A.
1920. Dr W. Burns, D.Sc.
1921. Dr. B. Sahni, M.A., D.Sc.
1922. Dr. W. Dudgeon, Ph.D.
1923. Mrs. G. L. C. Howard, M.A.
1924. Prof. S. P. Agharkar, M.A., Ph.D., F.L.S.
1925. Prof. R. S. Inamdar, B.Ag., B.A.
1926. Rev. E. Blatter, S.J., Ph.D., F.L.S.

Geology.

1914. Sir H. H. Hayden, Kt., C.S.I., C.I.E., D.Sc. F.A.S.B., F.R.S.
1915. Dr. W. F. Smeeth, M.A., A.R.S.M., F.G.S.
1917. C. S. Middlemiss, Esq., C.I.E., M.A., F R.S.
1918. E. S. Pinfold, Esq., B.A., F.G.S.
1919. Dr. L. L. Fermor, O.B.E , A.R.S.M., F.A.S.B.
1920. P. Sampatiengar, Esq.
1921. D. N. Wadia, Esq., M.A , B.Sc.
1922. G. H. Tipper, Esq., M.A., F.A.S.B.
1923. Dr. E. H. Pascoe, M.A., D.Sc., F.G.S.
1924. Dr. W. F. Smeeth, M.A., A.R.S.M., F.G.S.
1925. Dr. G. E. Pilgrim, D.Sc., F.G.S.
1926. Prof. B. Sahni, M.A. (Cantab), D.Sc. (Lond.), F.G.S.

(There was no Section of Geology in 1916.)

Medical Research.

1919. Lt.-Colonel W. Glen Liston, C.I.E., M.D., D.P.H., I.M.S.
1920. Lt.-Colonel W. F. Harvey, C.I.E., M.A., M.D., D.P.H., I.M.S.
1921. Lt.-Colonel J. W. D. Megaw, B.A., M.D., I.M.S.
1922. Major Cunningham, B.A., M.D., I.M.S.
1923. Major H. W. Acton, I.M.S.
1924. Lieut.-Col. S. R. Christophers, C.I.E., O.B.E., M.B., F.R.S., I.M.S.
1925. Lieut.-Col. F. P. Mackie, O.B.E., M.D., M.Sc., F.R.C.S., F.R.C.P., I.M.S.
1926. Dr. R. Row, M.D., D.Sc., (Lond.), L.M.S.

Anthropology.

1914. L. K. Anantakrishna Ayyar, Esq., M.A.
1915. H. V. Nanjundayya, Esq., C.I.E., M.A.

1921. Rai Bahadur Sarat Chandra Roy, M.A., B.L., M.L.C.
1922. Rai Bahadur Hiralal, B.A., M.R.A.S.
1923. Shams-ul-Ulama Dr. Jivanji Jamshedji Modi, B.A., Ph.D., C.I.E
1924. Rao Bahadur L. K. Ananthakrishna Ayyar, B.A., L.T., F.R.A.I..
1925. P. C. Mahalanobis, Esq., M.A., B.Sc.
1926. N. Subramaniya Iyer, Esq , M.A.

(There were no separate meetings of the Section of Anthropology in intermediate years.)

Psychology.

1925. Dr. N. N Sen-Gupta, M.A., Ph.D.
1926. Haridas Bhattacharya, Esq., M.A., B.L., P.R.S.

CHAIRMEN OF THE LOCAL COMMITTEE.

1919. Sir Dorab J. Tata.
1920. The Hon'ble Mr. J. F. Dyer.
1921. Sir Asutosh Mukherjee, Kt.
1922. Hon. Sir Lionel Davidson, K.C.S.I., I.C.S.
1923. Hon. Mr. C. Y. Chintamani.
1924. Sir B. N. Seal, Kt.
1925. Pandit Madan Mohan Malavya.
1926. Sir C. H. Setalwad, Kt., LL.D.

LOCAL SECRETARIES.

1914. D. Hooper, Esq.
1915. Dr. J. L. Simonsen.
1916. Prof. P S. MacMahon.
1917. Prof. H. E. Watson.
1918. A. S. Hemmy, Esq.
R. S. Ruchi Ram Sahni, Esq., M.A.
1919. A. Normand, Esq.
D. D. Kanga, Esq.
1920. M. Owen, Esq.
V. Bose, Esq.
1921. Dr. E. P. Harrison.
Dr. Hassan Suhrawardy.
1922. Capt. C. Newcomb, M.D., A.I.C., I.M.S.
Khan Sahib Md. Azizullah Sahib Bahadur, B.A., M.B., C.M.
1923. Prof. P. S. MacMahon.
Dr. Wali Muhammad.
1924. Prof. F. L. Usher.
S. A. Ramaswami Iyer, Esq.
1925. Prof. L. D. Coueslant, B. Sc., A.M.I.M.E.
Prof. K. K. Mathur, B.Sc., A.R.C.S.
1926. A. J. Turner, Esq., J.P., B.Sc., F.I.C.
Prof. G. R. Paranjape, M.Sc., I.E.S.

ACCOUNTS.

I.

Account of the Indian Science Congress for the year ending the 31st December, 1926.

Expenditure.				Receipts.			
Dr.				**Cr.**			
	Rs.	A.	P.		Rs.	A.	P.
By printing ..	4,142	3	0	To balance ..	4,658	2	11
,, Salary ..	470	0	0	,, Subscriptions .. (for the Bombay meeting 1926 and part of subscriptions for the Lahore meeting 1927).	6,425	3	0
,, Postage ..	545	4	0				
,, Indexing ..	60	0	0				
,, Contingencies ..	88	0	9				
,, Advance ..	193	0	0				
,, Balance ..	7,924	14	2	,, Sale proceeds of tickets at Benares Session .. (Balance recovered from Local Secretaries in Benares on a/c the Benares meeting 1925).	1,040	0	0
				,, Contribution received from Nagpur University (1926-27) ..	100	0	0
				,, Contribution from A.S.B. for the year 1926	1,200	0	0
Total Rs. ..	13,423	5	11	Total Rs. ..	13,423	5	11

Sd. Sunder Lal Hora,
Honorary Treasurer,
Asiatic Society of Bengal.

II.

Preliminary Statement showing the Income and Expenditure of the Reception Committee of the Indian Science Congress, 1927.

Expenditure.				Receipts.			
Dr.				**Cr.**			
	Rs.	A.	P.		Rs.	A.	P.
Dinner	2,250	0	0	Government of the Punjab ..	2,500	0	0
Printing charges for the Souvenir book..	1,163	5	0	University of the Punjab	1,500	0	0
Other printing charges	358	14	0	Donations, etc. ..	3,050	0	0
Harappa :— Rs. a.p.				Harappa Tickets ..	1,236	12	0
N.-W. Ry. 1,566-0-0				Delegates Fee enrolled in Lahore ..	2,443	0	0
Tonga and Lorry hire 155-2-6	1,721	2	6	Interest	28	0	3
Hire of Furniture ..	442	5	0	Miscellaneous receipts	3	6	9
Remuneration to Laboratory-assistants	445	0	0				
Telephones ..	125	0	0				
Remitted to Asiatic Society of Bengal, Calcutta ..	2,443	0	0				
Bank charges ..	5	14	0				
Miscellaneous :—							
Electrical fittings .. Rs. a.p. 276-0-0							
Tents and cartage .. 113-8-0							
Cloth for boards and paintings 84-14-0							
Hire of palms, etc. 131-6-0							
Hire of lorries and petrol for excursions 30-0-0							
Petty expenses, consisting of postage telegrams, tonga hire, from Rly. station to and from, for Volunteers and other minor items .. 1,094-0-6							
	1,729	12	6				
	10,684	5	0				
By balance in hand ..	76	14	0				
Total Rs. ..	10,761	3	0	Total Rs. ..	10,761	3	0

Sd. Anand Kumar,
Treasurer.
3-11-'27

Printed by P. Knight, Baptist Mission Press, Calcutta.

Proceedings

of the

Indian Science Congress.

Published by the Asiatic Society of Bengal.

First	Session, 1914,	Calcutta (1st Circuit) ..	Price Rs. 0-12-0.
Second	,, 1915,	Madras	Out of print.
Third	,, 1916,	Lucknow	Price Rs. 1- 8-0.
Fourth	,, 1917,	Bangalore	Out of print.
Fifth	,, 1918,	Lahore	,, ,,
Sixth	,, 1919,	Bombay	Price Rs. 3- 0-0.
Seventh	,, 1920,	Nagpur	,, ,, 3-12-0.
Eighth	,, 1921,	Calcutta (2nd Circuit) ..	,, ,, 4-14-0.
Ninth	,, 1922,	Madras	,, ,, 5- 4-0.
Tenth	,, 1923,	Lucknow	,, ,, 7- 8-0.
Eleventh	,, 1924,	Bangalore	,, ,, 6-12-0.
Twelfth	,, 1925,	Benares	,, ,, 9- 0-0.
Thirteenth	,, 1926,	Bombay	,, ,, 12- 6-0.
Fourteenth	,, 1927,	Lahore	,, ,, 9-12-0.

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